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Improving Energy Performance in Canada

Report to Parliament under the *Energy Efficiency Act*

2000–2001




CANADA'S **NATURAL RESOURCES**:
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Rapport au Parlement en vertu de la Loi sur l'efficacité énergétique, *2000-2001*

Her Excellency the Right Honourable Adrienne Clarkson,
C.C., C.M.M., C.D.
Governor General of Canada and Commander-in-Chief

Your Excellency,

I have the honour to present the *Report to Parliament Under the Energy Efficiency Act* for the fiscal year ending March 31, 2001, in accordance with section 36 of the Act.

Respectfully submitted,

Herb Dhaliwal
Minister of Natural Resources

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Minister's Foreword

This eighth report under the *Energy Efficiency Act* describes what Natural Resources Canada (NRCan) has done in 2000-01 to help improve Canada's energy efficiency. From 1990 to 2000, Canada's energy efficiency improved by 9.4 percent. In 2000 alone, Canadians saved $8.7 billion in energy costs and reduced greenhouse gas emissions by 38.3 megatonnes.

These reductions are important in our efforts to mitigate the effects of climate change. We must address this challenge now because, as energy-intensive human activities release more greenhouse gases into our atmosphere, world climatic conditions are changing in some very serious and fundamental ways. Canadians must do their part to lessen the effects of climate change – as citizens of a large, northern country, we rely in large part on our use of energy to maintain our high standard of living. Therefore, our international commitment to reduce greenhouse gas emissions recognizes our responsibilities, our abilities and our needs.

In 2000, the Government of Canada committed more than $1.1 billion over five years to climate change initiatives aimed at reducing the greenhouse gas emissions from our energy use. Many of the practical, concrete measures included in *Action Plan 2000 on Climate Change* are well under way, making key contributions to improving Canada's energy performance.

Through this plan and its regular programs, NRCan promotes energy efficiency, renewable energy and alternative transportation fuels. It also provides information, training and incentives, and supports innovative research and development to help Canadians improve their energy use.

These initiatives share three characteristics. First, they reflect the conviction of the Government of Canada that innovation is the key to success in the knowledge-based, highly skilled and technology-driven "new economy" of the 21st century. Second, they incorporate working with other organizations – making progress through partnerships – as an essential element. No one government, no one sector, no one industry, no one country can find the answers to climate change alone. We share the problem, and we must work together to deal with it. Third, these initiatives make good policy sense in their own right, quite apart from their link to climate change. They are cost-effective, practical and build on one another. They target key sectors which, when taken together, account for 90 percent of Canada's emissions.

The Government of Canada continues to provide the tools that Canadians need to improve their energy performance while safeguarding the environment. With our partners, we are proving that we can find ways to reap the benefits of all of our resources – both natural and knowledge-based – to sustain our quality of life, now and for the future.

Herb Dhaliwal

Herb Dhaliwal
Minister of Natural Resources Canada

Executive Summary

Canadians enjoy abundant, reliable sources of energy available at reasonable prices. This abundance contributes to our high standard of living, but it comes at a cost – we use more energy per person than people in most other countries. Canada is an energy-intensive country due to its cold climate, a relatively small population distributed over a large land area creating a high demand for transportation services, an energy-intensive industrial base (e.g. pulp and paper, iron and steel production, mining) and modest energy prices.

There are two types of energy use: primary and secondary. Primary energy use represents the total for all users of energy, energy used in transforming one form to another (e.g. coal to electricity) and energy used by suppliers in providing energy to the market (e.g. pipeline fuel). The consumption of energy in the residential, agriculture, commercial and institutional, industrial and transportation sectors comprises secondary energy use. This eighth annual Report to Parliament focuses on secondary energy use.[1]

Canadians spend almost 10 percent of their gross domestic product on secondary energy use. This represents almost $104 billion per year spent on energy to heat and cool our homes, to operate our appliances and cars and for industrial processes.

Secondary energy use accounted for 70.3 percent (8164 petajoules) of primary energy use in 2000. It was responsible for about 65.6 percent (474 megatonnes) of total greenhouse gas (GHG) emissions in Canada (including indirect emissions produced by electrical utilities to meet end-use demands). From 1990 to 2000, secondary energy use increased by 16.7 percent (from 6999 to 8164 petajoules). At the same time, GHG emissions attributable to secondary energy use increased by 16.3 percent (from 407 to 474 megatonnes).

In general, the more energy Canadians use, the more GHG emissions produced and the greater the impact on global climate change. Improved energy efficiency reduces GHG emissions and helps slow climate change. Since 1991, Natural Resources Canada (NRCan) has been leading the way in reducing GHGs in Canada with its energy efficiency and alternative energy (EAE) initiatives. These numerous EAE initiatives are the cornerstone upon which Canada is further expanding its National Implementation Strategy on Climate Change.

EAE initiatives decrease the amount of energy required for a given level of service (energy efficiency), such as improving motor vehicle fuel efficiency, or replace carbon-intensive energy sources with energy generated from sources that produce fewer or no GHG emissions (alternative energy), such as wind power.

Most of Natural Resources Canada's EAE initiatives deal with energy efficiency in the residential, commercial and institutional, industrial and transportation sectors. NRCan's alternative energy initiatives focus on developing alternative sources of energy and encouraging their use.

Six key policy instruments support these EAE initiatives:

- *leadership* by the Government of Canada setting an example for other levels of government and the private sector;
- *information programs* to inform energy users of the benefits of energy efficiency and to increase awareness and adoption of energy-efficient technologies and practices;
- *voluntary initiatives* that support actions by energy users to improve their energy efficiency;

[1] Information on total secondary energy use in 2000 was collected on five sectors, four of which are reported here. The fifth sector, agriculture, which accounted for 2.8 percent of total secondary energy use in 2000, is not reported.

- *financial incentives* to encourage investment in energy efficiency infrastructure and technologies by final users of energy;
- *regulations* that set minimum performance standards to eliminate less energy-efficient products from the market; and
- *research and development* to find solutions and implement best practices and applications in energy efficiency.

Four main factors affect energy use in all reported sectors – residential, commercial and institutional, industrial and transportation:

- *activity* – Increases in activities in the same sector lead to increased energy use and emissions. For example, in the residential sector an increase in the number of households increases energy use.
- *structure* – A shift from less energy-intensive activities in one sector toward more energy-intensive activities in another sector leads to increased energy use and GHG emissions. For example, a shift from activities in the forestry sector to activities in the iron and steel industry increases energy use and emissions because the industry is more energy intensive.
- *weather* – Fluctuations in the weather can lead to increased or decreased energy use. For example, a colder winter means more heating, and a warmer summer means more cooling.
- *energy efficiency* – The efficiency of a product or piece of equipment depends on how effectively it uses or saves energy. For example, well-insulated windows save energy.

These factors contributed to the increase of Canada's use of secondary energy (16.7 percent between the years 1990 and 2000). Activity raised secondary energy use by 27.1 percent (1845 petajoules). Changes in structure, though, decreased secondary energy use by 0.8 percent (108 petajoules). At the same time, weather increased secondary energy use by 1.3 percent (40 petajoules).

If only these three factors – activity, structure and weather – had been in effect, secondary energy use would have increased by 26.1 percent. However, improvements in energy efficiency worked to decrease energy use by 8.7 percent (661 petajoules). As a result, energy use increased by only 16.7 percent. The difference in energy use represents a reduction in energy costs of $8.7 billion a year and a reduction in GHG emissions of over 38 megatonnes.

The Minister of Natural Resources Canada, under the *Energy Efficiency Act*, is required to table an annual report before Parliament. This annual Report – the eighth – contains many indicators that quantify the progress of NRCan's EAE initiatives in the 2000–2001 fiscal year. Since many factors (including the four above) affect energy consumption, it is not always possible to establish a clear causal link between the EAE initiatives and their impact on energy use and/or efficiency. However, the progress indicators do show changes in trends or patterns that may be used to indirectly establish program outcomes. These indicators are being further refined, and additional indicators are being developed to link cause and effect more clearly.

Residential Sector

The residential sector was the third largest energy user, accounting for 17.0 percent of total secondary energy use and 15.8 percent of GHG emissions in 2000. The greatest energy efficiency improvement occurred in this sector (15.1 percent).

Between 1990 and 2000, residential energy use increased by 6.8 percent. GHG emissions from the residential sector increased by 7.3 percent in the same period. When combined, these two increases in GHG emissions reflect an increase in GHG intensity, mainly due to an increase in the carbon intensity of electricity.

Residential Sector EAE Initiatives and Selected Progress Indicators

NRCan promotes energy efficiency in new houses through the following:

R-2000 Program – encourages Canadians to voluntarily build houses that are more energy efficient and environmentally responsible.

- An R-2000 house costs 38 percent less to heat than a conventional new house.

Model National Energy Code for Houses – aims to increase energy efficiency by specifying minimum performance standards for new Canadian homes.

Buildings Energy Technology Advancement (BETA) Plan – Residential Buildings – provides technology development and transfer, as well as quality assurance, to promote energy-efficient and environmentally responsible technologies for housing.

In existing houses, NRCan promotes energy efficiency through the following:

EnerGuide for Houses – encourages Canadians to improve the energy efficiency of their homes, especially when undertaking home renovation and maintenance projects.

- In its second year of operation, the EnerGuide program evaluated more than 9100 houses, almost twice as many as it did in its first year. On average, potential energy savings of the houses were 25 percent of their energy use; the actual or realized savings following the evaluation was more than 13 percent of their energy use.

In equipment, NRCan promotes energy efficiency through the following:

Energy Efficiency Regulations – contribute significantly to the energy efficiency of appliances sold in Canada.

- Between 1990 and 2000, the energy consumption of new appliances decreased by substantial amounts, from 19 percent (clothes dryers) to 62 percent (dishwashers).

EnerGuide for Equipment – encourages consumers to purchase energy-efficient household appliances, room air conditioners and heating, ventilating and air-conditioning equipment.

- Nineteen percent of refrigerators with top-mounted freezers in 2001 were high-efficiency models, according to the *EnerGuide Appliance Directory 2001*.

Commercial and Institutional Sector

The commercial and institutional sector accounted for 13.0 percent of total secondary energy use and 12.6 percent of GHG emissions in 2000. This sector ranked fourth in energy efficiency improvement (2.6 percent).

Between 1990 and 2000, commercial and institutional energy use increased by 22.1 percent. However, GHG emissions from the sector rose by 25.3 percent in the same period. The increased use of energy sources with a higher GHG content was the main reason that emissions increased more quickly than energy use.

Commercial and Institutional Sector EAE Initiatives and Selected Progress Indicators

In new commercial and multi-use apartment buildings, NRCan promotes energy efficiency through the following:

Model National Energy Code for Buildings (MNECB) – aims to increase energy efficiency by specifying the minimum performance for new buildings in Canada.

Commercial Building Incentive Program (CBIP) – provides financial incentives to builders and developers to incorporate energy-efficient technologies and practices into the design and construction of new commercial, institutional and multi-unit residential buildings.

- Under CBIP, a developer must construct a building that is at least 25 percent more efficient than the MNECB. During CBIP's first three years of operation, recipients of CBIP incentives realized energy consumption levels 25 to 65 percent lower than those set out in the MNECB.

BETA Plan – Large Buildings – supports the development, commercialization and industry adoption of energy-efficient, environmentally responsible technologies for large commercial buildings and high-rise residential structures.

In existing commercial and federal sector facilities, NRCan promotes energy efficiency through the following:

Energy Innovators Initiative (EII) – helps commercial organizations and public institutions explore energy efficiency options and strategies.

- In its first three years, the EII Pilot Retrofit Incentive approved 52 projects representing more than 8 million m^2 of space. These projects will reduce energy costs by $21 million and will reduce energy consumption by about 20 percent on average, based on a total investment of $208 million ($8.8 million from the incentive).

Federal Buildings Initiative – promotes energy efficiency implementation strategies for federally owned and/or occupied facilities and buildings.

Federal Industrial Boiler Program – assists its clients in increasing their energy efficiency, reducing nitrous oxide emissions and extending the useful life of existing heating and cooling systems and auxiliary equipment.

In equipment, NRCan promotes energy efficiency through the following:

Energy Efficiency Regulations – encourage the development and use of energy-efficient equipment in commercial and institutional buildings.

- The Regulations for the commercial and institutional sector have reduced the annual energy use by 20 percent for the 2.40-m (8-ft.), high-output fluorescent lamp and by 15 percent for the 1.2-m (4-ft.) medium bi-pin lamp, two of the most popular fluorescent lamps.

Buildings Program – develops and transfers refrigeration and intelligent buildings technologies in partnership with industry and provides technical support for disseminating ground-source heat pumps.

Industrial Sector

The industrial sector was the largest energy user, accounting for 39.2 percent of total secondary energy use and 33.6 percent of GHG emissions in 2000. This sector ranked third in energy efficiency improvement (8.7 percent).

After decreasing slightly during the period 1990 to 1991 as a result of the recession, industrial energy use had increased by about 16.3 percent by the year 2000.

Industrial Sector EAE Initiatives and Selected Progress Indicators

NRCan promotes energy efficiency in the industrial sector through the following:

Industrial Energy Efficiency – provides a framework for a voluntary industry-government alliance to achieve greater energy efficiency in Canada's manufacturing and mining sectors.

- Between 1990 and 2000, 31 of 34 industrial sectors improved their energy intensity. The electric and electronic, glass, gold, rubber and beverage industries made the most notable intensity improvement, realizing efficiency gains of 41 to 75 percent.

Industry Energy Research and Development Program – supports the development and application of energy-efficient and environmentally responsible processes, products, systems and equipment in industry.

Emerging Technologies Program – supports the identification and demonstration of new energy-efficient technologies.

Industrial Process Integration Program – supports the development and adoption of process integration in various industries.

Industrial Process Engineering Program – enables industry to improve energy efficiency and productivity while decreasing GHGs and other emissions.

Advanced Combustion Technologies Program – helps industry develop cleaner, more energy-efficient combustion processes.

Energy Technologies for High Temperature Processes Group – investigates technologies and develops knowledge to ensure the sustainability of Canada's coal, carbon and metallurgical industries.

Processing and Environmental Catalysis Program – helps solve industrial process problems and conducts research in areas with high potential for significant environmental and economic benefits.

Minerals and Metals Technologies Initiative – helps Canada's minerals and metals industries to improve energy efficiency and reduce energy costs.

In equipment, NRCan promotes energy efficiency through the following:

Energy Efficiency Regulations – encourage the development and use of energy-efficient products in the industrial sector.

- Since 1997, the Regulations for the industrial sector have raised the standard for industrial motors by about 5 percent. The aggregate annual energy savings in the industrial sector from the 1997 amendment are estimated to be 5.9 petajoules in 2005 and will increase to 11 petajoules by the year 2020.

Transportation Sector

The transportation sector was the second largest energy user, accounting for 28.0 percent of total secondary energy use and 34.5 percent of GHG emissions in 2000. This sector ranked second in energy efficiency improvement (10.7 percent).

Transportation energy use increased by more than 21.5 percent between the years 1990 and 2000. Passenger transportation energy use increased by almost 12.6 percent, while freight transportation energy use rose by 34.1 percent.

Transportation Sector EAE Initiatives and Selected Progress Indicators

NRCan promotes the production and purchase of more energy-efficient personal vehicles and the use and maintenance of personal vehicles in more energy-efficient ways through the following:

Motor Vehicle Fuel Efficiency Initiative – helps vehicle manufacturers voluntarily improve motor vehicle fuel efficiency.

- The average on-road fuel consumption of the total stock of light-duty vehicles in Canada improved by 2.1 percent between the years 1990 and 2000. These improvements occurred in the face of a trend toward heavier, more powerful vehicles in the latter part of the 1990s.

EnerGuide for Vehicles – informs consumers about the fuel efficiency of new light-duty vehicles to help them choose the most fuel-efficient vehicle that meets their needs.

Auto$mart – encourages and assists motorists to buy, drive and maintain their vehicles in energy-efficient ways that save fuel and money and emphasizes how such efforts also reduce vehicle emissions.

NRCan increases energy efficiency and the use of alternative transportation fuels in commercial fleets through the following:

FleetWise – helps managers of Government of Canada fleets to improve their operational efficiency and accelerate the use of alternative fuels.

- Since the FleetWise initiative was launched in 1995, the federal fleet of on-road civilian vehicles has decreased by about 10 percent, and annual fuel consumption of the fleet has declined by almost 12 percent.

Fleet$mart – improves fuel efficiency and alternative transportation fuels in non-federal vehicle fleets.

NRCan promotes the energy efficiency, development and use of alternative transportation fuels and alternative transportation fuel vehicles through the following:

Transportation Energy Technologies Program – disseminates transportation technologies to minimize environmental impacts, increase the potential for job and economic growth and extend the life span of Canada's energy resource space.

Future Fuels Initiative – encourages the development, production and use of alternative and future vehicle and fuel technologies.

- The number of fuelling stations selling ethanol-blended gasoline increased from 266 in 1990 to 1140 in 2000.

Renewable Energy

NRCan also delivers several important initiatives to encourage the development and use of emerging renewable energy sources (e.g. solar, wind, water, bioenergy) and technologies.

In 1998, renewable energy sources accounted for about 17 percent of Canada's primary energy use. Most renewable energy in Canada comes from either hydro-electricity or thermal energy from biomass, such as wood-waste sources.

Renewable Energy Initiatives and Selected Progress Indicators

NRCan increases the use of small-scale, renewable energy in Canada through the following:

Renewable Energy Capacity Building Program – promotes the dissemination of renewable energy systems in Canada and abroad.

Renewable Energy Deployment Initiative – stimulates demand for renewable energy systems for space, water heating and cooling.

Renewable Energy Information and Awareness Program – expands the use of renewable energy technologies and stimulates the growth of the renewable energy industry.

Renewable Energy Market Assessment Program – reviews renewable energy resources and use and determines the potential of commercially available technologies for meeting Canada's energy needs and environmental goals.

Green Power Initiative – encourages federal departments to buy electricity from renewable energy sources, with NRCan setting the example.

Renewable Energy Technologies Program – supports efforts by Canadian industry to develop renewable energy technologies.

- Since 1990, in addition to wind power in remote, off-grid communities, the number of large wind turbines connected to the grid has increased. As of March 2000, Canadian wind-power capacity increased to about 125 megawatts.

Photovoltaic and Hybrid Systems Program – supports the development and application of solar photovoltaic technologies in Canada.

Energy From the Forest Program – undertakes research and development on forest biomass for energy.

Community Energy Systems

NRCan works in partnership with Canadian businesses and communities to meet their energy needs with greater efficiency and increase the use of renewable energy through the following:

Community Energy Systems Program – provides planning and implementing services for projects in urban centres and remote communities, moving the communities toward increased sustainability.

A Co-operative Approach

Working together with stakeholders, NRCan's EAE initiatives target all energy consumers to improve energy efficiency and reduce GHG emissions – helping to slow climate change. NRCan co-operates with provincial and territorial governments to deliver many of its EAE programs to reduce energy costs, increase competitiveness, improve air quality and generate economic and trade opportunities. Co-ordination between federal and provincial/territorial levels is essential to avoid duplication and ensure efficient program delivery.

NRCan also works with municipal governments to improve energy efficiency in Canadian communities. Globally, NRCan co-operates with several international organizations and foreign governments to improve energy efficiency programs and to help reduce trade barriers through harmonizing test and performance standards. In addition, NRCan also serves on a number of committees and undertakes studies on energy efficiency and related issues. The private sector is also a crucial player in the success of NRCan's EAE initiatives.

Private Sector Input

NRCan's collaboration with Canada's private sector creates a solid foundation to continue to improve energy performance in Canada. Many of NRCan's achievements in the last reporting year involve the Canadian private sector in consultations and joint projects, voluntary programs and a variety of activities, such as workshops, conferences/symposiums, market and research studies, verification tests and awards programs.

Introduction

Greenhouse Gases and Climate Change

The consensus of many in the scientific community is that the average global temperature continues to rise as a result of continuing buildup in levels of anthropogenic (human-produced) greenhouse gases (GHGs) in the atmosphere in addition to naturally occurring emissions. GHGs are constituted by carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and chlorofluorocarbons (CFCs). The main source of anthropogenic emissions is CO_2 from the combustion of fossil fuels. Substantially reducing GHG emissions is a challenge, particularly given Canada's highly industrialized and resource-based economy. Solutions require a multi-faceted, co-ordinated domestic response and a high level of co-operation among all nations.

The Kyoto Protocol and Canada's Commitment to Reduce GHG Emissions

In December 1997, Canada and more than 160 other countries met in Kyoto, Japan, and agreed to targets to reduce GHG emissions. The Kyoto Protocol is the agreement that set out those targets and the options available to countries to achieve them. Canada's target is to reduce its GHG emissions to 6 percent below 1990 levels by the first commitment period (2008 to 2012).

After signing the Kyoto Protocol, Canada established a National Climate Change Process with provinces, territories, stakeholders and the Canadian public to examine the potential impacts, costs and benefits of the protocol and possible options for its implementation.

In October 2000, a National Implementation Strategy on Climate Change was approved with the release of *Canada's First National Climate Change Business Plan*, which set out concrete measures to reduce GHGs. Currently, the Government of Canada is facilitating comprehensive analytical work and full discussions with provincial and territorial governments as well as stakeholders, including industry and the Canadian public, on further possible options for domestic emissions reductions.

The *Government of Canada Action Plan 2000 on Climate Change* (Action Plan 2000) – the Government of Canada's contribution to the business planning process – is the foundation for current and future actions on climate change. Natural Resources Canada (NRCan) plays a leading role in achieving climate change solutions within recently announced Action Plan 2000 policies and measures. These initiatives have significantly increased the scope of funding and activity in the key areas of energy efficiency, technology developments and the promotion of alternative energy solutions.

Natural Resources Canada's Efficiency and Alternative Energy Program

Over the past decade, NRCan's emphasis has been to promote energy efficiency and the use of alternative energy as a means to reduce GHG emissions, particularly in relation to the Kyoto Protocol. NRCan's Efficiency and Alternative Energy (EAE) program was launched in 1991. A complete list of NRCan's EAE initiatives and expenditures in 2000–2001 are listed in Appendix 1. These initiatives engage Canadian society and all major sectors of the economy in new and more efficient approaches to secondary energy use – i.e., the consumption of energy in the residential, commercial and institutional, industrial and transportation sectors.

The *Energy Efficiency Act*, which came into force on January 1, 1993, gives the Minister of Natural Resources Canada the authority to enforce regulations concerning EAE. The *Energy Efficiency Regulations* promote products and equipment in the Canadian market that are more energy efficient by establishing minimum energy performance levels and prohibiting the import of, and interprovincial trade in, products and equipment that fail to meet these levels.

NRCan's EAE initiatives are managed by

- the Office of Energy Efficiency (OEE), which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels;
- the Canadian Centre for Mineral and Energy Technology (CANMET) Energy Technology Branch and the CANMET Mineral Technology Branch, which deliver EAE research and development initiatives;
- the Energy Resources Branch, which delivers market transformation initiatives for renewable energy; and
- the Science Branch of the Canadian Forest Service, which undertakes research and development in the use of forest biomass for energy.

In its efforts to reduce GHG emissions, NRCan emphasizes partnership and co-operation with stakeholders such as other levels of government, the private sector and non-governmental organizations. Using this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side, Canada participates in developing technology for tapping renewable energy resources and alternative transportation fuels as well as increasing the energy efficiency of production.

In This Report

This eighth annual Report to Parliament focuses principally on EAE initiatives that address secondary energy use. Organized into eight chapters, the report reviews the progress achieved by these initiatives during 2000–2001. Chapter 1 covers the policy context and applicable legislation. Energy use and GHG emissions in Canada are discussed in Chapter 2. Chapters 3 to 6 review the individual EAE initiatives in the residential, commercial and institutional, industrial and transportation sectors, highlighting their achievements and progress indicators. Chapter 7 deals with renewable energy sources and use as well as an initiative in energy efficiency and renewable energy in Canadian communities. The final chapter describes intergovernmental co-operation in EAE.

Chapter 1

Policy Context and Legislation

Federal Policy and Programs on Energy Efficiency and Alternative Energy

Energy use has been a policy concern since the 1970s. Governments responded to the oil crises of 1973 and 1979 by promoting energy conservation and renewable energy sources to reduce reliance on imported oil. At that time, most consuming countries regulated energy prices at below world levels.

By the mid-1980s, world oil shortages had become world oil gluts. Governments believed that the marketplace, left alone, would attain an optimal level of energy use and mix of energy sources. Thus they deregulated energy prices and markets and phased out most energy conservation and renewable energy programs.

By the end of the 1980s, however, individuals, organizations and governments around the world became concerned that greenhouse gas (GHG) emissions produced by burning fossil fuels – such as coal, oil and natural gas – could contribute to climate change.

In 1990, Canada's concern about its GHG emissions (which result mostly from energy use) spurred an expansion of federal programs designed to improve energy efficiency and increase the use of alternative energy sources, which took into account the need to

- ensure flexibility to respond to program experience and develop a clearer understanding of the opportunities for energy efficiency and alternative sources of energy;
- promote an internationally competitive Canadian industry and meet trade commitments; and
- meet other policy objectives, especially fiscal restraint.

The ongoing Energy Efficiency and Alternative Energy (EAE) program, launched by Natural Resources Canada (NRCan) in 1991, supports economically feasible increases in energy efficiency and the use of alternative energy sources. It encourages investment in corporate and consumer EAE opportunities, and it seeks to engage all sectors of the economy and Canadian society in rethinking and improving energy use (see Appendix 1 for a list of NRCan EAE program initiatives and expenditures in 2000–2001).

The EAE program uses a variety of policy instruments, including leadership, information, voluntary actions, financial incentives, research and development (R&D) and regulation. In all cases, it emphasizes partnership with stakeholders, such as other levels of government, the private sector and non-governmental organizations. In this manner, the program helps the demand side of the energy market move toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side of the energy market, the program ensures that Canada participates in the development of technology for tapping renewable energy sources and alternative transportation fuels, as well as increasing the energy efficiency of the production of energy.

The statutory authority improved data-gathering and analytical capabilities. In addition, information and planning links with strategic allies created by NRCan's EAE program provide a foundation for long-term processes that respond to evolving environmental and economic development priorities.

In 1992, Canada signed and ratified the *United Nations Framework Convention on Climate Change*. Under this convention, Canada and other countries agreed to work to stabilize GHG emissions at 1990 levels by 2000. On February 20, 1995, federal and provincial ministers of energy and the environment approved the National Action Program on Climate Change (NAPCC), which Canada tabled at the first meeting of the Conference of the Parties to the

Framework Convention in Berlin, Germany, in April 1995. The NAPCC included the promotion of energy efficiency in all sectors of the economy as a key strategic element.

To broaden awareness of the need to act and reinforce the impetus to voluntary action, federal and provincial ministers of energy and environment agreed in February 1995 to establish the Climate Change Voluntary Challenge and Registry (VCR). It was incorporated in October 1997 as a non-governmental, not-for-profit organization. Canada's Climate Change Voluntary Challenge and Registry Inc. (VCR Inc.) invites Canadian companies and organizations to develop action plans to limit their net GHG emissions and to file these, as well as progress reports and achievements, on its public registry which is posted on the Internet.

The federal budget of February 1997 provided $60 million over three years, commencing April 1, 1998, for new initiatives to improve energy efficiency in new commercial buildings; encourage commercial building retrofits; provide for energy performance assessments of houses; and stimulate demand for cost-effective, commercially available renewable energy systems for space and water heating and cooling. This funding was renewed in the February 2000 federal budget.

In December 1997, Canada participated in the third Conference of the Parties to the Framework Convention on Climate Change, held in Kyoto, Japan. Participating countries agreed to reduce GHG emissions from 1990 levels within the period of 2008 to 2012. Canada pledged to reduce its emissions by 6 percent. The Kyoto Protocol applies to the six most important GHGs. Although carbon dioxide (CO_2) accounts for about 76 percent of Canada's GHG emissions and its reduction is often considered the main solution to climate change, reducing the emissions of such gases as methane and nitrous oxide is also important.

Countries tried to reach agreement on the operating rules for the implementation of the Kyoto Protocol at the Sixth Conference of Parties (COP6) in The Hague, Netherlands, in November 2000. At that meeting, consensus could not be reached on all issues, and negotiations were suspended. COP6 negotiations resumed in Germany in July 2001, where political agreement was reached on major issues. Technical discussions continued in Morocco in fall 2001 at COP7 and at other international meetings. The Protocol will enter into force when at least 55 parties to the Framework Convention, representing 55 percent of industrialized countries' GHG emissions, have ratified it.

In early 1998, the federal, provincial and territorial governments established the National Climate Change Process to examine the impact, costs and benefits of the Kyoto Protocol and the implementation options open to Canada. From spring 1998 to winter 1999–2000, the process engaged more than 450 experts from across Canada. Their recommendations were provided to governments to help develop a national climate change implementation strategy for consideration by federal, provincial and territorial governments in fall 2000. NRCan officials provided a great deal of support, analysis, advice and guidance to the National Climate Change Process.

In February 1998, the federal budget provided $150 million over three years for a Climate Change Action Fund to help Canada develop its response to the Kyoto Protocol. This funding was renewed in the February 2000 federal budget. The fund has the following four components:

- *Public Education and Outreach* builds public awareness and understanding of climate change and encourages action to reduce GHG emissions;
- *Technology Early Action Measures* (TEAM) shares with the private sector the risk of demonstrating cost-effective technology projects that will lead to reductions in GHG emissions:
- *Science, Impacts and Adaptation* supports further research to advance our knowledge of the magnitude, rate and regional distribution of climate change and its impact on Canada, as well as helping to develop adaptation strategies; and

- *Foundation Analysis* supports the National Climate Change Process and the analysis of options for reducing Canada's GHG emissions.

In February 1999, the federal budget provided $1.6 million over three years to assist the Federation of Canadian Municipalities (FCM) to develop and implement the national Municipal Building Retrofit Program under a contribution agreement with NRCan. During 2000–2001, the FCM focused on active engagement and recruitment activities. The following products and services were developed: a "Green Leaf" municipal assessment and rating tool, municipal workshops and training seminars, a comprehensive program guide and resource material and a regional delivery framework with local delivery agents. These tools and services are being used to help municipalities identify, plan, implement, monitor and celebrate energy efficiency projects.

In January 2000, federal, provincial and territorial ministers of energy and the environment (Joint Ministers' Meeting, or JMM) announced the Baseline Protection Initiative (BPI) as one of the first major policy initiatives to be taken under Canada's National Implementation Strategy on Climate Change. The BPI is meant to remove possible disincentives to early actions that would reduce GHG emissions by allowing organizations to reconstruct their emissions baselines to reflect the impact of actions taken since January 1, 1990. BPI rules and guidelines governing action eligibility, tracking and reporting, as well as a variety of communications material, will be developed. An action validation service will be offered.

The BPI responds to a concern that organizations that are already working to reduce emissions might be disadvantaged if a future emissions-reduction policy is introduced that is based on historical emissions levels with no acknowledgment of previous efforts to reduce emissions. With baseline protection, should such a policy be introduced, the eligible reductions stemming from early action will be removed from the entity's baseline emissions. Under the BPI, reduction actions may be registered with VCR Inc. and ÉcoGESte. VCR Inc. is a not-for-profit organization aimed at encouraging voluntary GHG emissions reductions across all sectors of the Canadian economy. ÉcoGESte is a Quebec organization reporting to the Quebec Ministry of Natural Resources and to its Ministry of the Environment. It has a policy-making capacity and a registry with aims similar to those of VCR Inc.

As noted previously, the February 2000 budget continued funding for an additional three years for the four EAE initiatives announced in the February 1997 budget and the Climate Change Action Fund announced in the February 1998 federal budget.

The federal 2000 budget also provided funds for a Green Municipal Enabling Fund (GMEF) and a Green Municipal Investment Fund (GMIF). The FCM manages the two funds under agreements with NRCan and Environment Canada.

The Director General of the OEE sits on the Green Municipal Funds Council, of which one third of its members represent the Government of Canada. The Council reviews all applications put forward by the FCM and advises the FCM Board of Directors to accept or reject them.

The GMEF is a $25-million endowment, available for five years, to contribute to feasibility studies to assess the technical, engineering, environmental and/or economic viability of proposed energy and environmental projects in municipal operations.

The GMIF is a permanent, $100-million endowment to provide loans and loan guarantees to eligible recipients to carry out energy and environmental projects. The GMIF also provides grants and long-term loans for pilot projects that demonstrate innovative technologies and/or processes in applications that have an investment payback of more than 10 years.

Building on a successful initial purchase of green power in Alberta, the February 2000 federal budget expanded the pilot initiative to permit the procurement of $15 million in renewable energy over the next 10 years

for federal facilities in Saskatchewan and Prince Edward Island. The budget also indicated that the Government of Canada will strive to increase its purchases of green energy for federal facilities located in all regions of Canada.

In October 2000, the Government of Canada announced its Action Plan 2000 on Climate Change. Funding for the program was set at $500 million over five years, commencing in 2001–2002, and reflects the Government of Canada's contribution to the First National Climate Change Business Plan being developed with the provinces and territories. When fully implemented, the package of measures is expected to take Canada one third of the way to its Kyoto target by reducing GHG emissions by about 65 megatonnes per year.

The Action Plan captures some of the best ideas from Canada's national consultations on climate change. It targets key sectors and includes initiatives in transportation, energy supply, industry, buildings, forestry and agriculture, international projects, technology, science and adaptation. Reporting on NRCan's energy efficiency and alternative energy measures contained in Action Plan 2000 will commence with the next edition of this annual report, covering their implementation in 2001–2002.

In April 1998, the Office of Energy Efficiency (OEE) was established as part of NRCan, with a mandate to strengthen and expand Canada's commitment to energy efficiency in order to help address the challenges of climate change, particularly in relation to the Kyoto Protocol. The OEE's programs target all final energy consumers and emphasize partnerships and economic investment. Its program objectives are to overcome the market barriers posed by inadequate information and knowledge about energy efficiency and alternative transportation fuels, and to address institutional deterrents in energy-use markets and economic constraints that energy users face.

Under the direction of the Minister of Natural Resources, the OEE is also responsible for identifying opportunities for new and heightened energy efficiency measures. The National Advisory Council on Energy Efficiency assists in this work by providing advice and guidance to the OEE. The Council comprises energy efficiency experts and leaders from all sectors of the economy. The OEE also reports annually on the state of energy efficiency in Canada and has managed Canada's Energy Efficiency Conference in 1999 and 2000, along with two energy efficiency technology products and services trade shows, and continues to administer Canada's Energy Efficiency Awards.

NRCan's Office of Energy Research and Development (OERD) co-ordinates and funds non-nuclear, energy-related R&D for the Government of Canada in partnership with 12 federal departments and agencies. Each, in line with its own mandate, lends its physical resources and expertise to study issues that face Canada's energy sector. As a response to climate change and, more specifically, Canada's Kyoto commitments, OERD, through the Program of Energy Research and Development (PERD), dedicates more than 50 percent of its annual $58-million R&D budget to study options related to energy efficiency ($19 million) and alternative energy ($11 million). In addition, PERD directs some $5.4 million of its funding toward studies aimed at understanding climate change and developing mitigation or adaptation options related to it. The OERD also co-ordinates NRCan's response on energy science and technology (S&T) to government policy and program initiatives (for example, the Technology Innovation Strategy, which forms part of the National Implementation Strategy on Climate Change).

The energy S&T mission of NRCan's CANMET Energy Technology Branch (CETB) focuses on technology development and deployment. Technology development activities are performed on a cost-shared basis either through in-house R&D work at its laboratories or by providing funding support to its technology partners. Deployment and commercialization activities include support for standards development, technical workshops and conferences, training and full-scale

implementation. The CANMET Energy Technology Centre in Ottawa, Ontario, works in partnership with a range of stakeholders to develop and disseminate innovative, cleaner energy technologies, including energy-efficient technologies for homes, businesses and industry; renewable energy; alternative transportation fuels; district heating and cooling systems; advanced low-emissions combustion technologies; and energy-efficient metallurgical fuel products and technologies. The CANMET Energy Diversification Research Laboratory in Varennes, Quebec, is committed to developing technologies that use energy wisely and help Canadians stay competitive in the marketplace, such as advanced drying technologies, heat transfer and storage systems, photovoltaics, renewable energy for remote communities and related software tools such as RETScreen® International.

Along with the OEE, OERD and CETB, the Energy Resources Branch (ERB) is the remaining NRCan Energy Sector organization with programs reported in this document. Within the ERB, the Renewable and Electrical Energy Division promotes the development of a sustainable renewable energy industry in Canada. The division promotes investments in renewable energy systems for heating and cooling and provides information on renewable energy technologies. By strengthening markets for the renewable energy industry, its programs contribute to GHG reductions, job creation and export sales.

Energy Efficiency Strategy

Most of NRCan's EAE initiatives deal solely with energy efficiency. These initiatives are presented in Chapters 3, 4, 5 and 6 by end-use sector – residential, commercial and institutional, industrial and transportation. The goal of these initiatives is to improve energy efficiency by

- increasing the energy efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to purchase buildings, equipment, systems and vehicles that are more energy-efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way (e.g., furnaces are kept well-tuned and vehicles are operated at optimal speeds);
- influencing the energy-use practices of individuals and organizations (e.g., persuading people to walk, cycle or use public transit instead of driving their own vehicles); and
- developing technologies to give consumers, industry and communities new opportunities to improve energy efficiency.

Alternative Energy Strategy

In the short term, energy efficiency improvements can contribute significantly to energy savings and environmental objectives. In the long term, however, reducing GHG emissions to 1990 levels or below will probably require fundamental changes in how we produce and use energy. We will have to make considerably greater use of alternative energy sources and continue to make changes in how we use energy.

Alternative energy includes renewable sources other than large hydro-electric facilities (e.g., bioenergy and solar energy), new applications of conventional sources (e.g., natural gas or propane used as a transportation fuel) and new fuels such as hydrogen for vehicles powered by fuel cells. Large hydro is not considered an alternative energy source because it is already a successful, well-established mode of energy production, supplying more than 60 percent of the electricity in Canada. Some technologies, especially those that involve the use of forestry biomass and propane and natural gas in vehicles, are already commercially available and accepted. Some have found applications in specialized markets, such as remote communities. Other technologies are still in the early stages of development. Chapters 6 and 7 describe what NRCan is doing to help develop alternative sources of energy and encourage their use.

NRCan's activities emphasize the most technically promising and marketable alternative transportation fuels, such as

propane, natural gas and alcohol. Federal initiatives are helping to expand the infrastructure (e.g., fuelling stations) for the sale of these fuels, especially in urban areas, where the provision of infrastructure is more economic. R&D focuses on ways to improve options in the use of these fuels. Program areas include

- the development of alternative fuels and advanced propulsion systems – gaseous fuels, alcohols, hydrogen, fuel cells, electric vehicles, hybrids and related systems;
- advanced energy storage systems – lightweight cylinders, adsorption technologies and flywheels;
- emissions-control technologies – for diesel and alternatively fuelled engines, lean burn catalysts and enhanced combustion chamber design;
- vehicle transportation systems efficiency – advanced materials and processes, driving cycle analysis, auxiliaries and regenerative braking systems; and
- fuelling infrastructure – fuelling station hardware, hydrogen systems and battery-charging systems.

It is generally recognized that renewable sources of energy, such as hydraulic, biomass, wind and solar energy, can do much to mitigate climate change. NRCan allocates most of its support for renewable energy to R&D to reduce costs, improve performance, develop safety and performance standards and increase the scope of renewable energy technologies. The department also provides modest incentives for investments in renewable energy systems, disseminates information to consumers and assesses economic and environmental aspects of renewable sources of energy.

In 1996, NRCan released its *Renewable Energy Strategy – Creating a New Momentum*, a strategy to promote a strong and viable renewable energy industry in Canada. The strategy calls for the department to act as a catalyst in the development and marketing of renewable energy technologies. It aims to improve the environmental performance of the energy sector and to enhance the sustainability and diversity of Canada's energy mix.

Policy Instruments

NRCan's key policy instruments are

- leadership;
- information;
- voluntary initiatives;
- financial incentives;
- regulation; and
- research and development.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing the energy efficiency and use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates energy efficiency information to consumers, using methods that range from broad distribution to individual consultations with clients. The method depends on the client.

NRCan's broad range of marketing and communications activities aim to

- increase awareness among Canadians of the environmental impact of energy use; and
- encourage consumers to increase the efficiency of their energy use and switch to alternative sources of energy.

These activities include publications, exhibits, advertising, toll-free lines, conferences, Web sites, workshops and promotional products.

NRCan disseminates EAE information to the general public as well as to more specific audiences. It makes information available through a wide range of products on such topics as home and industrial energy efficiency, energy technology, renewable energy, heating systems, appliances, new buildings, energy-efficient transportation and alternative and future transportation fuels.

NRCan organizes and participates in a wide range of EAE-related conferences each year. In October 2000 it held Canada's second national conference, trade show and awards program on energy efficiency

in Ottawa, Ontario. Canada's Energy Efficiency Conference brought together national and international experts in energy efficiency, sustainable development, business and the environment. The conference's objectives were to

- facilitate the sharing of knowledge and position Canada's efforts and successes in energy efficiency within the global scene;
- identify, recognize and promote technological and program achievements;
- highlight policies, programs and pragmatic technologies that can help individuals and organizations to increase their knowledge of energy efficiency; and
- increase understanding of the important role of energy efficiency in addressing the problem of climate change.

A total of 582 delegates attended the conference, and 650 delegates and award nominees attended the awards ceremony. Canada's Energy Efficiency Trade Show, held concurrently with the conference and open to delegates and the general public, featured almost 50 exhibitors in the energy efficiency field. As part of the conference's Student Ambassador Program, 25 post-secondary students from across Canada won scholarships to attend the conference and give presentations. Also at the conference was the Energy Efficiency Career Resources Centre, presented in partnership with the Canadian Council for Human Resources in the Environment Industry.

Voluntary Initiatives

Companies and institutions work with NRCan on a voluntary basis to establish and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target large consumers of energy in the commercial, institutional and industrial sectors and organizations whose products (e.g., buildings, vehicles and equipment) are important determinants of energy use. In a typical initiative, an organization (e.g., a company, institution or association) agrees to take steps that will save money and reduce environmental impacts. The initiatives involve industry-government agreements and, for groups of large industrial energy users, energy efficiency target setting. NRCan provides a variety of support services to assist and stimulate action by companies and institutions on energy efficiency, including developing standards and training.

Financial Incentives

NRCan uses financial incentives to encourage final users of energy to employ energy efficiency and renewable energy technologies and practices when they acquire, design or build new buildings or retrofit existing ones. NRCan also offers financial incentives for natural gas vehicles and refuelling infrastructure.

Regulation

Regulation involves setting energy performance levels and labelling requirements for certain types of equipment and working with provincial governments to improve the energy efficiency provisions in Canadian building codes.

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations concerning EAE, primarily performance and labelling requirements for energy-using products (as well as doors and windows) that are imported or shipped from province to province. The Act also gives the Government of Canada the authority to establish regulations and to collect statistics and information on energy use and alternative energy.

Research and Development

NRCan's EAE initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. R&D also provides the scientific knowledge needed to develop technologies, codes, standards and regulations to make the use of energy comply with sustainable-development principles.

NRCan provides national leadership in energy S&T by undertaking in-house research in its own laboratories, by contracting out research activities to other organizations and through the federal PERD. PERD and TEAM are the only

federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

Figure 1 shows how these policy tools work together to increase energy efficiency, i.e., how they help to reduce the amount of energy needed to obtain a certain level of service.

Measuring Progress

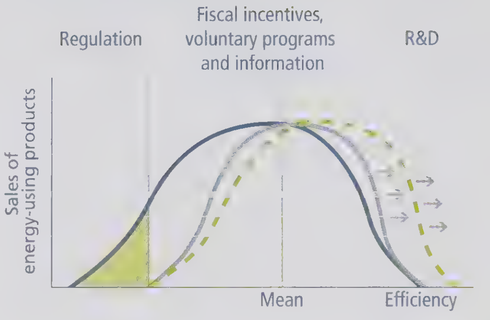
The primary goal of NRCan's EAE initiatives is to change energy consumption patterns to obtain environmental and economic benefits. To assess progress, three aspects of program delivery must be considered:

- program outputs;
- program outcomes; and
- market outcomes.

Program outputs are the items that a program produces regularly, such as information and marketing materials, training, demonstration projects, voluntary agreements, technology development, financial incentives and regulations. Program outputs are designed to lead to *program outcomes* – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would if there had been no program.

Since program outcomes directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable *market outcomes*. Market outcomes ultimately reflect the impacts of NRCan programs on changes in energy efficiency, energy intensity, the use of alternative energy and GHG emissions. An example of a market outcome is a householder's purchase of a more energy-efficient appliance and reduced use of electricity.

FIGURE 1
Moving the Market



Depending on the source of electricity and how the utility changes its electricity-generating methods to meet the change in demand, this could lead to a decline in GHGs.

Measuring program and market outcomes can be difficult. In particular, quantifying program outcomes requires client and data surveys and detailed analyses of energy use. NRCan's National Energy Use Database (NEUD) initiative (see sidebar on page 11) helps the department track changes in energy consumption at a disaggregated level. Nevertheless, it is still difficult to determine the incremental effects of programs because other factors, such as variation in energy prices, also influence these effects. Moreover, because several programs can influence a consumer at the same time, it is difficult to determine the separate contribution of each program to the total effect.

Recent implementation of results-based management of the PERD will provide better information on the results of its energy S&T investments.

This report uses a mix of progress indicators, which are quantitative where possible. However, the reader should bear in mind that it is difficult to determine incrementality and attribution when reviewing the outcome indicators. The challenge for NRCan is to continuously improve the coverage and quality of these progress indicators.

The *Energy Efficiency Act* and Regulations

The Act

The *Energy Efficiency Act*, which came into force on January 1, 1993, gives the Government of Canada the authority to make and enforce regulations concerning the EAE program, primarily

- energy performance levels for energy-using products, doors and windows that are imported into Canada or shipped from one province to another;
- energy labelling of energy-using products, doors and windows that are imported into Canada or shipped from one province to another (NRCan's energy-labelling initiatives are described in Chapter 3, "Residential Sector"); and
- the collection of statistics and information on energy use and alternative energy.

Under the Act, before a prescribed product is imported into Canada or shipped from one province to another, the dealer must submit an energy efficiency report that describes the product and its energy performance. Also, dealers that import prescribed products must provide the Canada Customs and Revenue Agency (CCRA) with an extra copy of the customs release documents, which indicate the nature of the products and the purpose of importation. The copy is forwarded to NRCan for compliance verification.

National Energy Use Database

NRCan launched the NEUD to improve its knowledge of energy consumption and energy efficiency at the end-use level in Canada and to support its analytical expertise. By improving NRCan's understanding of where and how energy is used in Canada, the database reveals opportunities to improve energy efficiency. Over time, the NEUD helps track the effectiveness of the programs designed to address these opportunities. In these ways, the database supports national efforts to mitigate the impact of energy use on the environment.

In conjunction with partners in government and the academic community, the OEE supports the development of energy end-use data in all sectors of the economy and the expansion of Canada's expertise in analysing energy use by

- reviewing existing data in each end-use sector (residential, agriculture, commercial and institutional, industrial and transportation);
- assessing the information needs in each sector;
- expanding existing surveys or creating new ones to meet these data needs; and
- managing a network of energy end-use data analysis centres for specific sectors at selected universities across Canada.

The NEUD has funded several surveys to collect data on the energy consumed at the end-use level, the characteristics of energy-using equipment and buildings, the attitudes of Canadian consumers toward energy use and the adoption of energy-efficient technologies. In 2000–2001, it undertook and completed data collection for a new survey, the Commercial and Institutional Building Energy Use Survey, and explored opportunities to collect data on transportation, residential and apartment energy use in Canada more effectively.

The OEE created a detailed end-use analysis framework that contributes to historical reviews of energy efficiency in Canada (such as *Energy Efficiency Trends in Canada*), as well as prospective analyses of energy use (such as *Canada's Energy Outlook*).

The Minister of Natural Resources has the authority to designate inspectors to ensure compliance with the Act and the Regulations. In addition, the Governor in Council may make regulations regarding

- the testing of energy-using products;
- the detention, disposition or destruction of seized goods;
- exemptions; and
- the implementation of the provisions of the Act.

The Regulations

The purpose of the *Energy Efficiency Regulations* is to

- implement mandatory performance requirements for energy-using equipment;
- eliminate less efficient energy-using equipment from the Canadian market;
- support mandatory labelling requirements; and
- establish procedures to ensure that products meet labelling and performance requirements.

Regulations under the *Energy Efficiency Act* prohibit the import of and interprovincial trade in energy-using products that fail to meet a prescribed level of energy efficiency and labelling requirements. NRCan establishes the products and levels and labelling requirements after conducting energy and economic analyses and consulting with stakeholders. The major stakeholders are the provincial and territorial governments, manufacturers of energy-using equipment and their associations, energy utilities and public interest groups.

In choosing products to regulate and their efficiency levels and labelling requirements, NRCan is guided by the following considerations:

- energy savings;
- economic attractiveness;
- impact on Canadian manufacturers; and
- harmonization with other jurisdictions, especially Canada's provinces and territories and the United States.

The Regulations state the required performance level and testing procedures for specific products. NRCan helps develop these standards when it funds and participates in standards-writing committees, under the auspices of CSA International.

Regulations under the federal *Energy Efficiency Act* complement energy efficiency regulations in British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec for products sold in these provinces. They also parallel regulations in the United States. The performance levels for products covered by the federal Regulations are largely harmonized with those prescribed in provincial regulations for the same products.

The main compliance activities of the program are to monitor the industry and to enforce the Regulations. To detect non-compliance, NRCan monitors the industry through various means. The Regulations set out the following three elements of the compliance system:

- Reporting – If an energy-using product is not already listed in the NRCan compliance database, dealers are required to provide NRCan with information on the product before it is imported or shipped from one province to another.
- Verification Mark – A certification organization must verify the energy performance of products to ensure that they meet energy performance levels set out in the Regulations. A province may also verify the energy performance of a product if the province's energy performance requirements meet or exceed those of the Government of Canada. No one can sell or lease a product until it has a verification mark.

- Customs Release Documents – Dealers who import a prescribed product must submit an extra copy of the customs clearance document to the CCRA, which sends NRCan a copy of the completed document every week. Alternatively, the dealer can provide specific data elements to the CCRA using electronic means. The data elements are transferred electronically to NRCan.

NRCan's approach to compliance is set out in the "Compliance Policy for the *Energy Efficiency Act* and the *Energy Efficiency Regulations*." Following are key elements of the compliance system:

- Monitoring imports – The Act and the Regulations require that dealers report the energy performance of prescribed products to NRCan before importing these products. NRCan ensures that the products meet performance requirements. Officials follow up on cases of non-compliance or incomplete customs information.
- Third-party monitoring – Third-party monitoring of affected products is the responsibility of independent certification organizations accredited by the Standards Council of Canada, such as CSA International, Underwriters Laboratories Inc. and Intertek Testing Services.
- Inspections – NRCan conducts periodic marketplace audits.

NRCan has produced the comprehensive *Guide to Canada's Energy Efficiency Regulations*, as well as fact sheets on several topics. These documents are available on the OEE Web site at http://oee.nrcan.gc.ca/regulations.

Achievements 2000–2001

- NRCan processed more than 180 000 records relating to the importation into Canada of more than 3 million prescribed products.
- More than 1100 new or revised model numbers were entered into NRCan's compliance database from energy efficiency reports received from dealers.
- Instances of non-compliance were handled on a case-by-case basis in accordance with the Compliance Policy.
- A Memorandum of Understanding between NRCan and the CCRA was signed in November 2000.
- NRCan finalized the document *Criteria for Equipment Energy Performance Verification Programs* in April 2000.

Regulatory achievements related to specific products are set out in Chapters 3, 4 and 5.

Chapter 2

Energy Use and Greenhouse Gas Emissions in Canada

Introduction

Canadians enjoy an abundance of energy from a variety of sources. Our high standard of living is partly attributable to Canada having a reliable supply of energy, which is available at a reasonable cost.

Owing to this abundant supply of energy, Canada has developed industries that have particularly strong energy demands. This comparative advantage in the supply of energy has also helped Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. As a result, Canada consumes more energy per capita than most countries.

The amount of money spent on energy indicates its importance to this country and its economy. Canadians spend almost $104 billion per year on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes (this comprises secondary energy use, explained under "Energy Use and Greenhouse Gas Emissions" following). This represents almost 10 percent of our gross domestic product. Although the economic importance of energy varies from region to region, energy is always fundamental to our way of life.

Energy Use and Greenhouse Gas Emissions

We typically speak of two types of energy use: primary and secondary. Primary energy use represents the total requirements for all users of energy, the energy in transforming one energy form to another (e.g., coal to electricity) and the energy used by suppliers in providing energy to the market (e.g., pipeline fuel). Secondary energy use is energy used by final consumers for residential, agricultural, commercial, industrial and transportation purposes.

Primary energy use in Canada today reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. Primary energy use increased by more than 19.5 percent between 1990 and 2000, from 9724 petajoules to 11 621 petajoules.

Secondary energy use (8164 petajoules) accounted for 70.3 percent of primary energy use in 2000. It was responsible for about 65.6 percent (474 megatonnes) of total GHG emissions in Canada, if we include indirect emissions – namely, those produced by electric utilities to meet end-use electrical demand. This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Carbon dioxide is the major greenhouse gas (GHG), representing the majority of Canada's GHG emissions. All subsequent references in this report to CO_2 and GHG include both emissions from the electricity used by secondary energy users and those that are attributable directly to secondary energy use.

Secondary energy use increased by 16.7 percent from 1990 to 2000; GHG emissions attributable to secondary energy use increased by only 16.3 percent because of a 0.3-percent decrease in the GHG intensity of energy users. By 2000, the oil share of secondary energy use had fallen

The aggregate energy use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for the purpose of energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix A of NRCan's *Energy-Use Energy Data Handbook 1990–2000*.

by 1.2 percentage points from 1990 levels, from 41.2 percent to 40.0 percent, and the natural gas share increased from 25.4 percent to 26.1 percent. The electricity share was stable, and the share of other fuels, mainly biomass, increased.

The industrial sector is the largest energy user, accounting for 39.2 percent of total secondary energy use in 2000. The transportation sector is the second-largest energy user at 28.0 percent, followed by the residential sector at 17.0 percent, the commercial and institutional sector at 13.0 percent and the agriculture sector at 2.8 percent.

Energy Efficiency

NRCan annually publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use (and GHG emissions) since 1990 and the contribution of key factors to these changes (i.e., variations in activity, structure, weather and efficiency):

- increases in sector *activity* lead to increased energy use and emissions. In the residential sector, for example, an increase in the number of households has the effect of increasing energy use;
- a shift in the *structure* of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter:
- fluctuations in *weather* lead to changes in space-heating and cooling requirements. A colder winter or a warmer summer can lead to increased energy use. The weather effect is most significant in the residential and the commercial and institutional sectors, where heating and cooling requirements account for the major share of energy use; and
- *energy efficiency* – the amount of energy used to provide a given level of service.

In this report, changes in energy efficiency are the net result after allowing for the changes in energy use due to changes in activity, structure and weather. To the extent that other factors that affect energy use have not been captured, this measure of energy efficiency improvement might overstate or understate the "actual" change. For example, in the industrial sector, there may have been changes in energy use due to shifts in the mix of products that have not been captured.

TABLE 1
Explanation of Changes in Secondary Energy Use, 1990 to 2000

	Sectors						
	Residential	Commercial–Institutional	Industrial	Transportation	Agriculture	Total	% Change
1990 Energy Use (PJ)	1300	867	2755	1878	199	6999	
2000 Energy Use (PJ)	1388	1059	3204	2282	232	8164	
Change in Energy Use (PJ)	88	192	449	404	33	1166	16.7
Explanatory factor (change due to)							
Activity	224.7	205.4	1004.7	410.3		1845.1	26.4
Structure	28.6	2.9	-316.7	177.5		-107.7	-1.5
Weather	31.6	8.3	N/A	N/A		39.9	0.6
Energy efficiency (PJ)	-196.6	-23.2	-239.2	-201.9	0	-660.8	-9.4
Other factors		-1.6		18.3	32.8	49.5	0.7

Secondary energy use increased by 16.7 percent between 1990 and 2000 (from 6999 to 8164 petajoules). Two factors contributed to this increase (see Table 1):

- activity (economic growth) raised secondary energy use by 26.4 percent (1845 petajoules); and
- changes in the structure of activity decreased secondary energy use by 1.5 percent (108 petajoules).

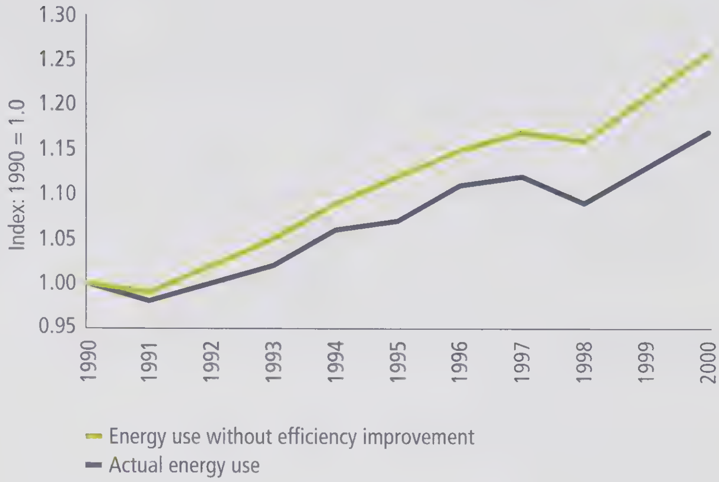
A third factor – weather – increased secondary energy use by 0.6 percent (40 petajoules); the winter of 2000 was colder than the winter of 1990, resulting in a higher demand for heating in the residential and commercial and institutional sectors.

If only these three factors had been in effect, secondary energy use would have increased by 25.4 percent. However, improvements in energy efficiency worked to decrease energy use by 9.4 percent (661 petajoules). As a result, energy use increased by only 16.7 percent. This change in energy use during 1990–2000, with and without changes in energy efficiency, is shown in Figure 2. The difference in energy use due to energy efficiency – the energy saving – represents a reduction in energy costs of $8.7 billion a year and a reduction in GHG emissions of over 38 megatonnes.

Changes in energy efficiency are estimated for each of the four major end-use sectors, using the approach described above and presented in Chapters 3 to 6. The energy efficiency improvements were largest in the residential sector (15.1 percent), followed by transportation (11.3 percent), industrial (8.7 percent), and commercial and institutional sectors (2.7 percent).

NRCan's programs contributed to a portion of the energy savings due to energy efficiency, as shown in Figure 2. The OEE is undertaking analysis to determine the portion of this energy saving that could be attributed to its programs. It is difficult, however, to separate the effects of NRCan's programs from those of other programs or normal marketplace changes. Moreover, many of the improvements in energy efficiency that have resulted from NRCan program initiatives undertaken between 1990 and 2000 have not had enough time to significantly affect total energy efficiency. Products that have been entering the market in the past few years constitute only a fraction of today's capital stock of energy-using equipment. It will take many years for recent energy efficiency improvements in new appliances and equipment to be fully revealed in the average efficiency of the Canadian stock of appliances and equipment. For example, new refrigerators sold in Canada are now 33 percent more energy efficient than those sold in 1990, primarily as a result of government regulations. However, it will take 15 years or more (the typical life of a refrigerator) before Canadian energy intensity figures fully reflect the 33-percent improvement. For these reasons, the following chapters do not, in most cases, quantify the energy use or GHG impact of NRCan's programs from 1990 to 2000. Rather, they examine a number of progress indicators to determine whether these programs are changing consumers' behaviour and advancing the adoption, or likely future adoption, of new technologies to improve energy use and reduce GHG emissions.

FIGURE 2
Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000



Chapter 3

Residential Sector

Energy Use and Greenhouse Gas Emissions

The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling, heating water and operating appliances and lights. This sector accounts for 17.0 percent (1388 petajoules) of secondary energy use and 15.8 percent (75 megatonnes) of greenhouse gas (GHG) emissions.

Most dwellings in Canada are single detached houses, followed by apartments, single attached dwellings and mobile homes (see Figure 3). Because single detached and attached houses predominate, most NRCan residential building programs focus on these dwellings.

Space and water heating make up 81.6 percent of residential energy use, followed by the shares devoted to operating appliances, lighting and space cooling (see Figure 4).

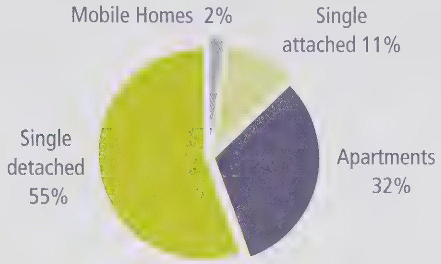
Between 1990 and 2000, residential energy use increased by 6.8 percent, or 88 petajoules (from 1300 to 1388 petajoules). GHG emissions from the residential sector increased by 7.3 percent from 1990 to 2000. A 6.8-percent increase in energy use combined with a 7.3-percent increase in GHG emissions reflects an increase in GHG intensity. This was principally due to an increase in the carbon intensity of electricity.

Four main factors tended to influence residential energy use – activity, weather, structure and energy efficiency:

- *activity* – the increase in the number of households and the size of dwellings (the principal measures of residential activity) increased energy use by 17.3 percent (225 petajoules);
- *weather* – colder weather in 2000 compared to 1990 led to an increase in space-heating requirements. This increased energy use by 2.4 percent (32 petajoules);
- *structure* – the percentage shares of energy end-uses changed over the period such that they increased energy use by 2.2 percent (29 petajoules); and
- *energy efficiency* – improvements in energy efficiency worked to decrease energy use by 15.1 percent (197 petajoules).

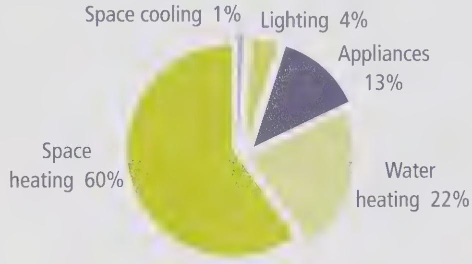
Growth in residential energy use was driven in large part by growth in activity. This increase was partially offset by significant improvements in energy efficiency. Structural changes had a minor impact on residential energy use.

FIGURE 3
Canadian Households by Type of Dwelling, 2000



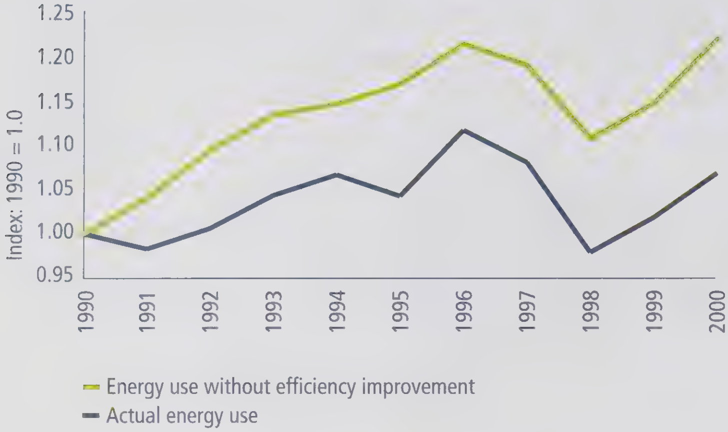
Total: 11 728 000 Households

FIGURE 4
Residential Energy Use by Purpose, 2000



Total: 1388.1 petajoules

FIGURE 5
Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000



The change in residential energy use from 1990 to 2000, as well as the energy savings due to energy efficiency, is shown in Figure 5.

NRCan delivers initiatives to increase energy efficiency in the following residential subsectors:

- new houses:
- existing houses; and
- residential equipment, including
  - energy performance regulations; and
  - energy labelling.

New Houses

NRCan promotes energy efficiency in new houses through the following initiatives:

- the R-2000 Program;
- the *Model National Energy Code for Houses*; and
- the Buildings Energy Technology Advancement (BETA) Plan – Residential Buildings.

R-2000 Program

The R-2000 Program encourages Canadians to build houses that are more energy efficient and environmentally responsible. To this end, NRCan encourages home builders to voluntarily build houses to the R-2000 Standard – a technical performance standard that exceeds the requirements for energy efficiency and environmental responsibility in current Canadian building codes. To ensure that every R-2000 home meets the required energy performance standard, NRCan trains and licenses home builders and other professionals across Canada in R-2000 construction techniques and practices and provides third-party quality assurance by certifying every R-2000 home. Ongoing research by NRCan, in collaboration with industry partners, ensures that the R-2000 Standard maintains its leading-edge position in the housing technology market. NRCan promotes the R-2000 Standard to builders, consumers and the construction industry.

NRCan manages the R-2000 Program, and more than 30 industry partners across Canada – such as energy utilities, home builders' associations, manufacturers, product suppliers and financial institutions – deliver it at the provincial level. As well, private-sector sponsors market the R-2000 Program in return for the publicity associated with the R-2000 name. The scope of the R-2000 Program grows with the changing needs of consumers to address such issues as indoor air quality, healthier homes and technological advancement.

Achievements 2000–2001

- NRCan worked with the Canadian Home Builders' Association (CHBA) and other stakeholders to ensure that the R-2000 Program is delivered in all regions across Canada. Contribution agreements for delivery of the R-2000 Program were put in place in all provinces and with the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) and the CHBA.
- A training package was developed for the new R-2000 Standard and was given in pilot training sessions to active R-2000 licensed builders and professionals in selected locations.

Model National Energy Code for Houses

The *Model National Energy Code for Houses* (MNECH) aims to increase energy efficiency by specifying minimum performance standards for new Canadian houses. It provides this customized energy standard by allowing for regional variations in climate and in energy and construction costs. Published by the Canadian Commission on Building and Fire Codes in 1997, the MNECH's development was supported by NRCan in collaboration with energy utilities, provincial and territorial governments and the National Research Council of Canada (NRC). NRCan encourages the adoption and implementation of the MNECH by relevant housing authorities (i.e., provinces, territories and municipalities). The department also monitors and analyses the impact of the MNECH.

Achievements 2000–2001

- During consultations under the National Climate Change Process (see page 4), the provisions of the MNECH provided a basis for considering measures to improve the energy efficiency of the Canadian housing stock.

Buildings Energy Technology Advancement (BETA) Plan – Residential Buildings

The BETA Plan – Residential Buildings provides technology development and transfer as well as quality assurance to promote energy-efficient and environmentally responsible technologies for new and existing housing. Priority is given to emerging technologies that can be used in new construction or retrofit projects (such as residential space- and water-heating systems); ventilation and windows; and the development of software to identify cost-effective retrofit opportunities. The BETA Plan – Residential Buildings also provides technical advice to the EnerGuide for Houses program, the R-2000 Program and the MNECH.

Achievements 2000–2001

- NRCan's ēKOCOMFORT™ project was announced at the Canadian Mechanicals Exposition in Toronto, Ontario, with funding from NRCan, the Technology Early Action Measures component of the Climate Change Action Fund (CCAF-TEAM) and the NRC's Industrial Research Assistance Program. This is a joint industry-government project to help manufacturers develop and test a new residential natural gas system that integrates ventilation, space- and hot-water heating and is called Advanced Integrated Mechanical Systems (AIMS). It also improves indoor air quality and reduces homeowner costs and GHG emissions. Six manufacturers are now developing, testing and installing AIMS products.

- NRCan delivered a series of training sessions on ESP-r software to participants from industry and academia. ESP-r is one of the world's most comprehensive and powerful building-simulation engines. It will be able to simulate advanced systems and building components, including AIMS, fuel cells and other self-generation devices. The goal is to establish a research network within Canadian universities and industry that will benefit Canadian software development efforts in the long term. NRCan also initiated funding to six universities related to this research network.
- NRCan signed a contribution agreement with Thermotech Windows Ltd. to finalize the development of an innovative, energy-efficient fibreglass-framed window. This project would reduce the cost of the frames and significantly enhance energy performance. These windows are triple-glazed and can have an energy rating of up to 12 W/m^2*, compared to −7 W/m^2 for average vinyl windows.
- NRCan hosted the second annual Super E™ members' forum in Vancouver, British Columbia. NRCan created the Super E™ program to help build industry expertise and export opportunities for Canadian energy-efficient housing. In Vancouver, the decision was made to begin moving the Super E™ group toward privatization. NRCan, with the Canada Mortgage and Housing Corporation, continued to actively promote the Super E™ program, taking part in several trade shows and seminars in Japan and one in Vancouver. To date, 41 Super E™ houses have been built, and approximately 32 new Canadian and Japanese members have joined the program. This is a twofold increase since 1999.

*Watts per metre squared.

Residential Sector: New Houses
Progress Indicators

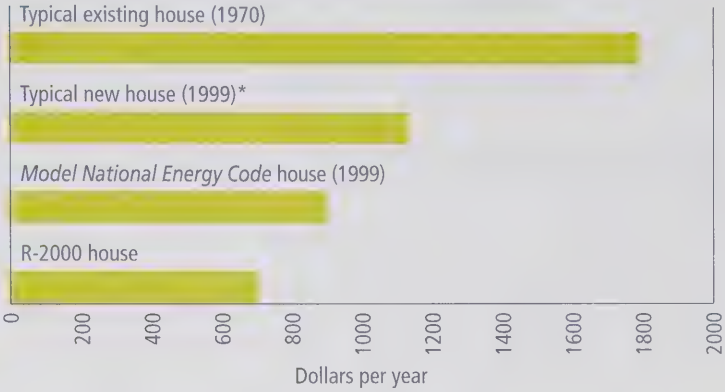
The three program initiatives described in the preceding three pages help reduce energy consumption in new residential units. For example, a new house in Ottawa, Ontario, that meets the MNECH costs about 21 percent less to heat than a conventional new house, whereas an R-2000 house costs about 38 percent less to heat (see Figure 6).

The proportion of R-2000 houses among new housing starts in the 1990s has declined substantially since 1993, from almost 1.0 percent to about one sixth of that level. The decrease is due in part to the fact that energy utilities in New Brunswick and Ontario discontinued their financial incentives in support of R-2000.

Because the R-2000 Program demonstrates readily available, energy-efficient building practices and technologies, it is more influential than the actual number of R-2000 houses would suggest. Mainstream home builders have increasingly adopted R-2000 practices and technologies and now incorporate some R-2000 energy efficiency principles in many (if not most) new houses.

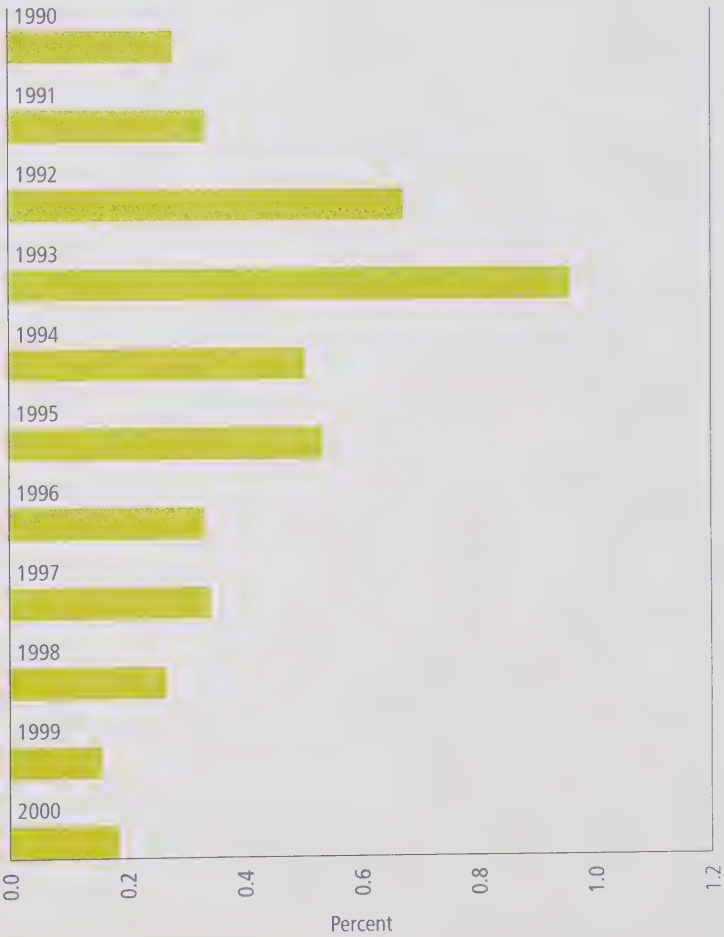
In 1999, conventional new houses rated at 70 to 73 points, as measured by the EnerGuide for Houses point rating scale (the current R-2000 Standard is 80 points). In 2000, conventional new houses rated at 70 to 74 points.

FIGURE 6
Annual Heating Costs for Houses Constructed to Different Standards, 1999



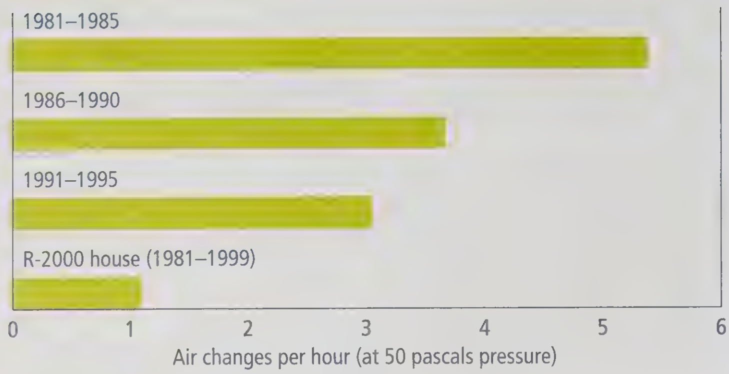
*198-m^2 single detached house heated with natural gas, Ottawa, Ontario.

FIGURE 7
R-2000 Share of National Housing Completions, 1990 to 2000



Progress Indicators (continued)

FIGURE 8
National Trends in Air Leakage in Houses by Construction Period



Existing Houses

NRCan promotes energy efficiency improvements in existing houses through the following initiatives:

- EnerGuide for Houses;
- Reno$ense; and
- BETA Plan – Residential Buildings (see page 21).

EnerGuide for Houses

The EnerGuide for Houses program encourages Canadians to improve the energy efficiency of their homes, especially when undertaking home renovation and maintenance projects. At the request of the homeowner, a qualified energy evaluator gathers energy-related information during a site inspection and undertakes a computerized analysis of the house's energy efficiency. The evaluator gives the homeowner a report that includes an estimate of the house's annual energy requirements, recommended energy efficiency improvements, and a label with an energy efficiency rating – the EnerGuide rating – which can be used to

- plan energy improvements and renovations;
- qualify for home improvement loans;
- obtain a second rating after the renovations to measure the improvement in energy performance;
- qualify home buyers for "green mortgages" by financial institutions; and
- compare the EnerGuide ratings of different houses when selling or buying a home.

This initiative raises consumer awareness of the benefits of energy efficiency, such as cost savings, improved comfort and indoor air quality, durability and the resale value of a house. Third parties deliver this initiative under licence from NRCan. They hire and train energy assessors and quality control personnel and provide local marketing and delivery. NRCan provides national co-ordination, technical support, quality assurance, software tools and training, generic information materials and national marketing.

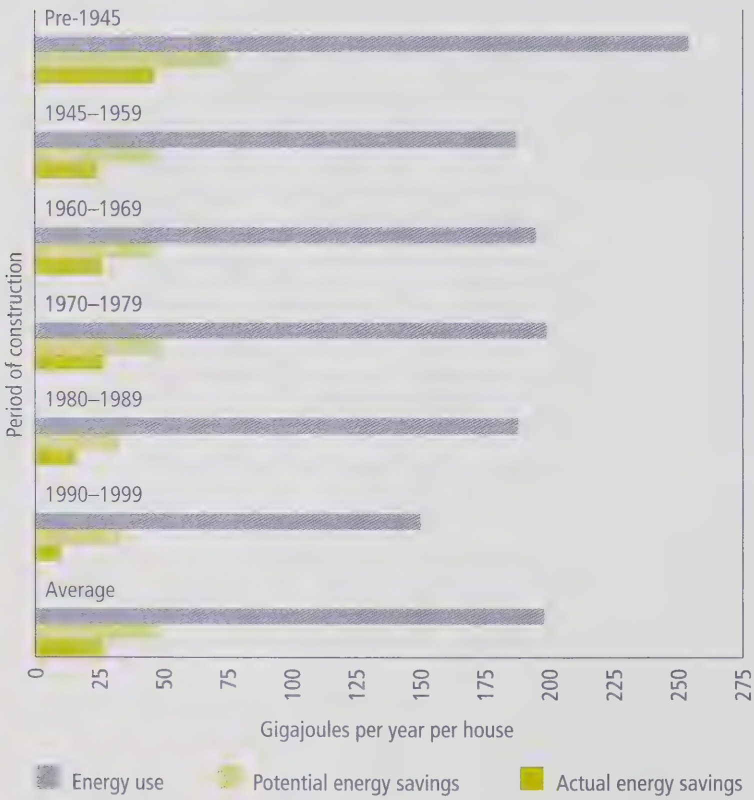
Achievements 2000–2001

- NRCan expanded the EnerGuide for Houses program to be available to 80 percent of the Canadian population. The department also made an effort to make the program more accessible in rural areas.
- The average annual energy savings for houses that took some retrofit activities was 17.8 percent.
- NRCan launched two promotional campaigns and participated in nine home shows and trade shows.

Progress Indicators

FIGURE 9
Homes Evaluated and Labelled Under the EnerGuide for Houses Program

FIGURE 10
Energy Use and Energy Savings – EnerGuide for Houses Program



In its second year of operation, the EnerGuide for Houses program evaluated almost twice as many houses (more than 9100) as it did in its first year (almost 4700) (see Figure 9). These houses were built at different times using different construction methods. They represent different levels of energy use, potential for energy savings and actual energy savings realized in conjunction with the program (see Figure 10). On average, the potential energy savings of the houses was 25 percent of their energy use; the actual or realized energy savings following the evaluation was more than 13 percent of their energy use.

Equipment

NRCan promotes energy-efficient equipment through the following initiatives:

- *Energy Efficiency Regulations*; and
- EnerGuide for Equipment.

The BETA Plan provides technical support for the EnerGuide initiative.

Energy Efficiency Regulations

Under the authority of the *Energy Efficiency Act*, NRCan sets *Energy Efficiency Regulations* for selected types of energy-using equipment to eliminate less energy-efficient products from the market. The Regulations prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy performance levels and labelling requirements. The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. NRCan funds and participates in nationally accredited standards-writing committees administered by CSA International to foster the development of these standards.

Achievements 2000–2001

- NRCan finalized an amendment to the Regulations that requires more stringent energy performance for refrigerators, combination refrigerator-freezers and freezers. The regulations, which will be published in 2001–2002, represent an improvement of 29.5 percent over the previous regulations for a typical size (16.5–18.4 cu. ft.) type 3 refrigerator.
- Workshops were held with stakeholders on the proposed regulations for dry-type distribution transformers.
- Workshops were held with stakeholders on proposed EnerGuide labelling and a proposed performance standard for gas fireplaces.
- Market studies were completed on gas furnaces to determine the impact of proposed regulations.
- A draft proposal to regulate the thermal performance of windows, skylights and sliding glass doors was distributed to stakeholders.
- NRCan was represented on the Strategic Steering Committee on Performance, Energy Efficiency and Renewables (SCOPEER). NRCan actively participated on 20 technical subcommittees that moved forward with the publication of seven standards (four additional standards were finalized and await publication).

EnerGuide for Equipment

The purpose of the EnerGuide for Equipment program is to encourage consumers to purchase energy-efficient products (household appliances, room air conditioners and heating, ventilating and air-conditioning [HVAC] equipment). This is done by showing a label with the energy performance of the product and comparing it with competing products of the same class.

NRCan's EnerGuide label is delivered under two systems:

- mandatory – through regulations; and
- voluntary – through agreement with product manufacturers.

EnerGuide labels for major household appliances are mandatory and describe energy performance as the number of kilowatt-hours (kWh) that an appliance consumes in a year (see Figure 11). EnerGuide labels for room air conditioners describe energy performance as an energy-efficiency ratio, or EER (see Figure 12). Both labels give consumers consistent, verifiable energy efficiency information they can use when shopping for appliances.

FIGURE 11
EnerGuide Label for Appliances

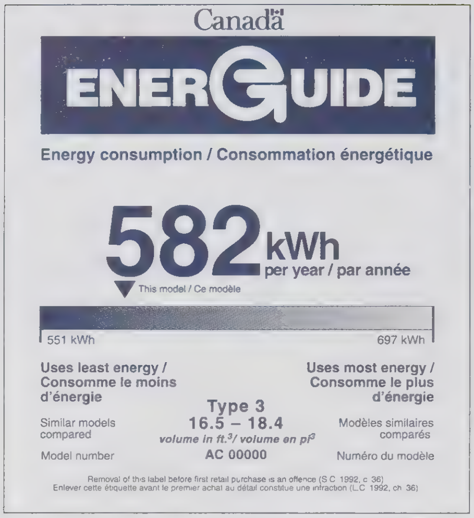
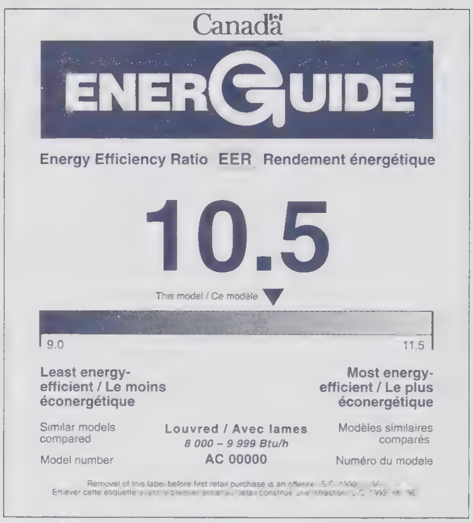


FIGURE 12
EnerGuide Label for Air Conditioners



The EnerGuide appliance label has two significant features. First, it states the annual energy consumption of the product, based on standardized test procedures prescribed in the Regulations. The annual consumption figure enables the buyer to calculate the operating cost of the product model. Second, for consumers who prefer a visual comparison, the label shows the performance range of products in a product class for a given year, using a graphic to indicate how the energy consumption of the model compares with that of other models of the same product.

NRCan selects products to bear the EnerGuide label in consultation with stakeholders. It implements marketplace monitoring and enforcement systems through audits on the frequency of labelling. NRCan also conducts public information campaigns to explain the EnerGuide label and the benefits of energy efficiency. Working with its partners, NRCan offers awareness programs for retail salespeople, supports media campaigns and staffs exhibits for major consumer home shows.

Regulations under the *Energy Efficiency Act* include labelling requirements for eight major household appliances, as follows:

- electric clothes dryers;
- clothes washers;
- dishwashers;
- electric ranges;
- freezers;
- integrated stacking washer-dryers;
- refrigerators and combination refrigerator-freezers; and
- room air conditioners.

NRCan's voluntary EnerGuide rating system for HVAC products is delivered in partnership with the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI). Manufacturers of HVAC equipment feature an EnerGuide rating in their product brochures. The EnerGuide rating indicates the energy performance of a product and how this compares with ratings ranging from a regulated minimum standard to the best available efficiencies, based on standardized testing. HRAI provides NRCan with a bi-annual report on shipments and aggregate efficiencies.

Achievements 2000–2001

- NRCan, in co-operation with HRAI and the Canadian Oil Heat Association, adopted an EnerGuide rating system for oil furnaces, whereby manufacturers and dealers would include the information on the back of their product brochures.
- NRCan officials finalized discussions with their counterparts in the U.S. Environmental Protection Agency and the U.S. Department of Energy regarding the use in Canada of the ENERGY STAR® mark and the associated energy efficiency specifications.

Residential Sector: Equipment
Progress Indicators

FIGURE 13
Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 1999

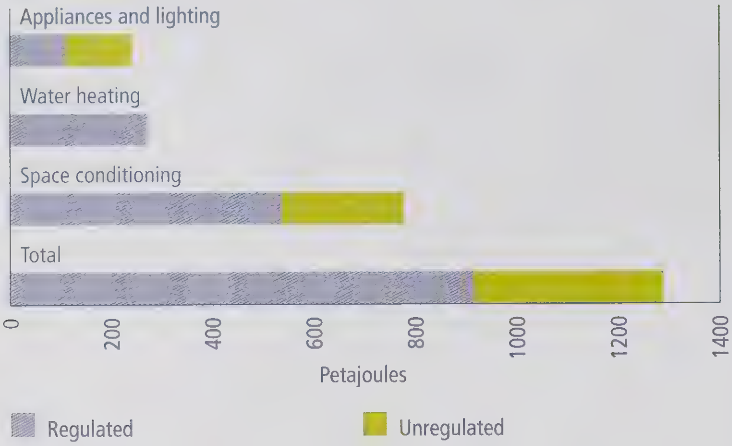
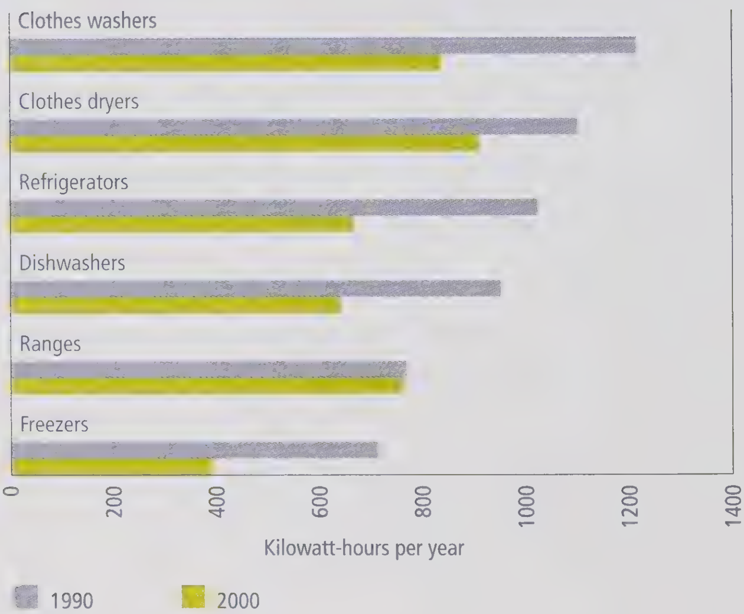


FIGURE 14
Average Energy Consumption of New Appliances, 1990 and 2000



The Regulations apply to equipment that accounts for 71 percent of total residential energy consumption, almost all of the energy consumed for water heating, 69 percent of the energy used for heating, ventilating and air-conditioning (HVAC) and 46 percent of the energy used to operate appliances and lighting.

The Regulations have significantly affected the energy efficiency of appliances sold in Canada. The energy consumption of new appliances has decreased by substantial amounts, from 19 percent (clothes dryers) to 62 percent (dishwashers).

The Regulations also greatly influenced the average efficiency of natural gas furnaces. Since 1990, low-efficiency natural gas furnaces have disappeared from the market, mid-efficiency furnaces have increased their market share from 16 to 62 percent and high-efficiency furnaces have increased their market share from 22 to 38 percent. The minimum efficiency specified in the Regulations is 78 percent; the maximum attainable with current technology is 96 percent.

Progress Indicators (continued)

By helping consumers compare the energy performance of equipment sold in Canada, the EnerGuide label gives manufacturers who produce energy-efficient products an opportunity to highlight their best-performing models. Nineteen percent of refrigerators with top-mounted freezers listed in the 2001 *EnerGuide Appliance Directory* (see Figure 16) showed high efficiency ratings that exceeded the regulated minimum energy-efficiency standard by 20 percent. Similarly, for dishwashers, 34 percent of the models listed in the Directory achieved high efficiency levels of at least 25 percent more than the regulated minimum energy-efficiency standard and 17 percent of standard-sized high-efficiency clothes washers listed in the Directory exceeded the minimum energy-performance standard by 50 percent or more. These figures highlight the positive relationship between the Regulations and the labelling initiatives. Without EnerGuide labels, manufacturers would have little incentive to provide more products with energy-efficiency levels above the regulated minimums.

FIGURE 15
Natural Gas Furnace Sales by Efficiency Level, 1990 and 1999

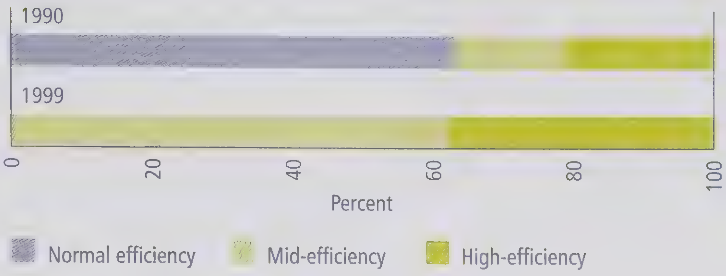
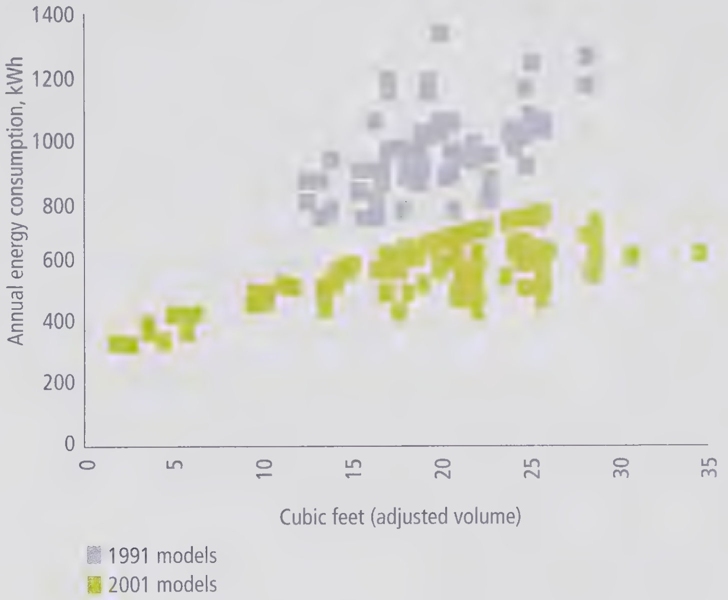


FIGURE 16
Unit Energy Consumption for Top-Mount Auto-Defrost Refrigerators Marketed in Canada, 1991 and 2001 Models



Chapter 4
Commercial and Institutional Sector

Energy Use and Greenhouse Gas Emissions

The commercial and institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services, including tourism. This sector uses energy mainly for space and water heating, space cooling, lighting, motive power for services such as pumping and ventilation in buildings, and street lighting.

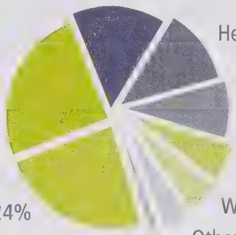
In 2000, the commercial and institutional sector accounted for 13.0 percent (1059 petajoules) of secondary energy use and 12.6 percent (59.9 megatonnes) of greenhouse gas (GHG) emissions.

This sector comprises many building types (see Figure 17). Retail and office space account for nearly half of commercial and institutional sector energy demand. Schools, health care facilities, and hotels and restaurants account for another 35 percent of that demand. NRCan programs address all of these major energy-using building types.

Energy is used for six purposes in commercial and institutional buildings. The largest of these is space heating, which accounts for more than half of this sector's entire energy demand (see Figure 18). Each of the remaining five uses of energy in this sector accounts for between 4.0 and 14.0 percent of its energy demand.

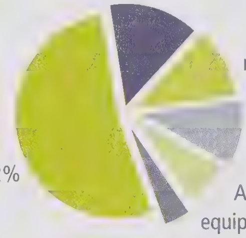
Between 1990 and 2000, commercial and institutional energy use increased by 22.1 percent, or 192 petajoules (from 867 to 1059 petajoules). However, GHG emissions from the sector rose by 25.3 percent in the same period. The main factor causing emissions to increase more quickly than energy use was the increased use of energy sources with a higher GHG content.

FIGURE 17
Commercial and Institutional Energy Use by Building Type, 2000



Total: 1051.5 petajoules
(excludes 7 petajoules for street lighting)

FIGURE 18
Commercial and Institutional Energy Use by Purpose, 2000

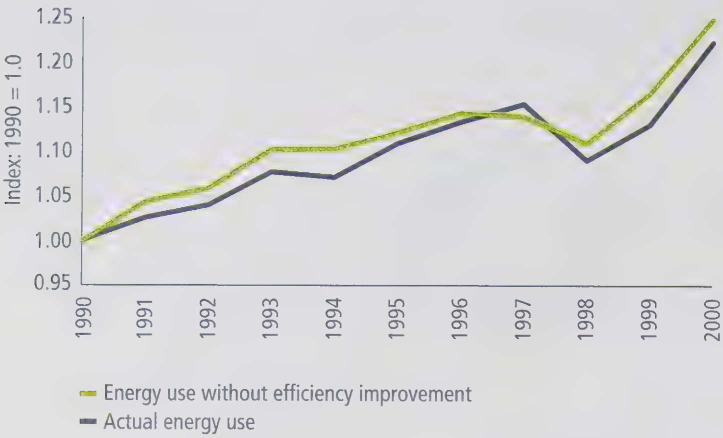


Total: 1051.5 petajoules

During the period 1990–2000, activity was the main factor tending to increase energy use; energy efficiency tended to decrease energy use. Structure (the mix of building types) and weather varied by only a minor extent. Specifically, the changes attributed to each of these factors are

- *activity* – an increase of 205 petajoules in energy use;
- *weather* – an increase of 8 petajoules;
- *energy efficiency* – a decrease of 22 petajoules; and
- *structure* – an increase of 3 petajoules.

FIGURE 19
Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000



If only activity, weather and structure had been in effect, commercial and institutional energy use would have increased by 25.0 percent (217 petajoules). However, improvements in energy efficiency worked to decrease energy use by 2.7 percent (23 petajoules). As a result, energy use increased by only 22.1 percent. This change in energy use during 1990 to 2000, as well as the energy savings due to energy efficiency, is shown in Figure 19.

NRCan delivers initiatives to increase energy efficiency in the following subsectors of the commercial and institutional sector:

- new buildings;
- existing buildings; and
- equipment.

New Buildings

Three initiatives address energy efficiency in new commercial and multi-use apartment buildings:

- the *Model National Energy Code for Buildings* (MNECB);
- the Commercial Building Incentive Program (CBIP); and
- the BETA Plan – Large Buildings.

Model National Energy Code for Buildings

The MNECB aims to increase energy efficiency by specifying minimum performance standards for new buildings in Canada. It provides these customized energy standards by allowing for regional climate and energy and construction cost variations. Published by the Canadian Commission on Buildings and Fire Codes in 1997, its development was supported by NRCan in collaboration with energy utilities, provincial and territorial governments and the National Research Council of Canada. NRCan encourages the adoption and implementation of this model code by relevant building authorities (i.e., provinces, territories and municipalities). The department also monitors and analyses the impact of this code.

Achievements 2000–2001

- During consultations under the National Climate Change Process (see page 4), the provisions of the MNECB provided a basis for considering measures to improve the energy efficiency of the building stock in Canada.

Commercial Building Incentive Program

CBIP provides financial incentives to builders and developers to incorporate energy-efficient technologies and practices into the design and construction of new commercial, institutional and multi-unit residential buildings. CBIP seeks to encourage a permanent change in the way such buildings are designed. It is intended to offset the extra cost of designing energy-efficient buildings and thus encourage designers and developers to consider efficiency options in their designs of commercial and institutional buildings. To qualify for the incentive, buildings must be at least 25 percent more efficient than buildings that meet the requirements of the MNECB. CBIP provides a one-time grant based on the difference in estimated annual energy costs between an approved CBIP design and an MNECB design. In addition to financial incentives, CBIP provides design software and guidelines, case studies and training for architects and engineers.

Achievements 2000–2001

- Fifty-nine contributions worth more than $2.5 million in total were issued to building owners on approval of their designs for energy-efficient buildings.

Buildings Energy Technology Advancement (BETA) Plan – Large Buildings

NRCan's BETA Plan – Large Buildings supports the development, commercialization and industry adoption of energy-efficient, environmentally responsible technologies for large commercial buildings and for high-rise residential structures. Its S&T activities are designed to identify the benefits and costs associated with introducing environmentally friendly, energy-efficient technologies. The C-2000 Program is one component of the BETA Plan – Large Buildings. It aims to accelerate the adoption of new technologies by demonstrating how energy efficiency, indoor environment and the environmental impact of commercial buildings can be improved through an integrated approach to design and renovation. The BETA Plan – Large Buildings provides technical advice to CBIP.

Achievements 2000–2001

- NRCan signed a contribution agreement with the ATHENA™ Sustainable Materials Institute to expand the capabilities of its life-cycle assessment tool (a project undertaken by NRCan and the Technology Early Action Measures component of the Climate Change Action Fund [CCAF-TEAM]). The new software program allows for the estimation of GHG emissions and other environmental considerations for structural elements and building materials. The improved software significantly aids the architecture, engineering and construction industries with its assessments of the life-cycle impacts of building construction.

- NRCan played a leading role supporting Canadian team participation at the Sustainable Buildings 2000 conference held in the Netherlands. The conference focused on the work of countries involved in the NRCan-led Green Building Challenge (GBC) process. The GBC entails the development and testing of a new method of assessing the environmental performance of buildings. More than 20 countries are now part of this challenge. The Canadian team presented the results of three building assessments and displayed the results in a national pavilion on-site.
- A new Mountain Equipment Co-op store opened in Ottawa, Ontario. NRCan contributed financially to the project and was involved on a consultative basis. It is the first retail store in Canada to comply with NRCan's C-2000 Program and CBIP. CBIP provides financial support for a building to be 25 percent more energy efficient than a comparable building constructed to the MNECB; C-2000 requires a building to be 50 percent more energy efficient than a comparable building and to incorporate other green features.
- NRCan released an updated version of the EE4 software. This software is used by architects and engineers to demonstrate compliance with CBIP and the C-2000 Program. In response to user and client requests, the new version of EE4 was developed to provide the following: additional modelling capabilities that include a dual-fan dual duct HVAC system model; the option for users to specify humidity control for their HVAC systems; and an upgrade to the DOE-2 calculation engine. There are now more than 500 registered industry users across Canada.

Commercial and Institutional Sector: New Buildings

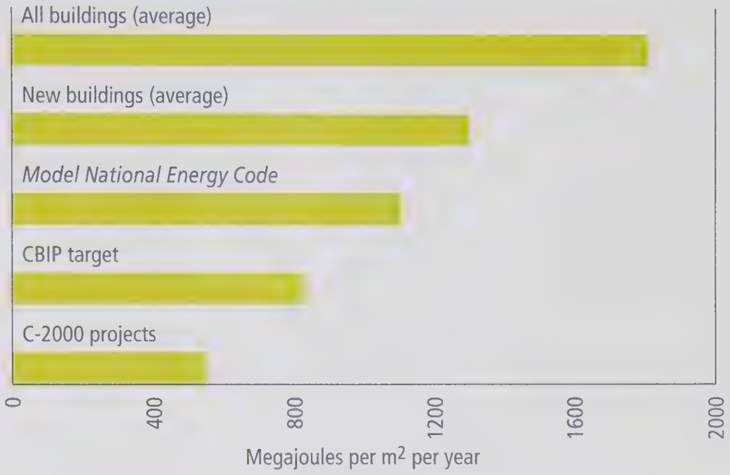
Progress Indicators

Because Canada's provinces and territories have jurisdiction over construction regulations, the MNECB comes into force only if it is incorporated into provincial or municipal building codes. By March 2000, the City of Vancouver, British Columbia, had formally committed to adopting the MNECB, and the Province of Ontario had specified it as one of two options to demonstrate good practices required for all new buildings in the province. Commercial buildings that meet the MNECB would use 15 percent less energy than those built to current standards (see Figure 20).

To qualify for incentives under CBIP, a developer must construct a building that is at least 25 percent more efficient than the MNECB. During CBIP's first three years of operation, recipients of CBIP incentives realized energy consumption levels 25 to 65 percent lower than set out in the MNECB.

Under the C-2000 Program, NRCan invited private industry to develop an advanced commercial building to meet stringent energy efficiency design criteria. C-2000 buildings use about 55 percent less energy than conventional buildings (see Figure 20).

FIGURE 20
Energy Use in Commercial Buildings, 1999



Existing Buildings

NRCan encourages energy efficiency improvements in commercial, institutional and federal sector facilities through

- the Energy Innovators Initiative (EII);
- the Federal Buildings Initiative; and
- the Federal Industrial Boiler Program (FIBP).

NRCan produces a twice-monthly newsletter specifically for these sectors, *Heads Up Energy Efficiency*. In fiscal year 2000–2001, subscriptions increased from approximately 2500 to 4500.

The OEE also sponsors the "Dollars to $ense" series of three training workshops. The workshops had more than 1000 registrants for the 2000–2001 fiscal year – 36.0 percent more than in 1999–2000. In the previous three years, more than 2200 Canadians found ways to save energy in their companies and organizations by attending one, two or all three workshops.

Energy Innovators Initiative

The EII helps commercial organizations and public institutions explore energy efficiency options and strategies. Member organizations can save money and help the environment through the reduction of GHG emissions related to energy consumption. The EII offers access to tools, services and financial assistance delivered through Energy Innovators officers who work with members as they pursue energy management planning and retrofits. Municipal Energy Innovators can access programs, grants and loans through the Federation of Canadian Municipalities.

Since 1992, more than 600 commercial and institutional organizations have joined the EII by sending a letter to the Minister stating their long-term commitment to energy efficiency. The EII also works in partnership with key sectoral associations, such as the Hotel Association of Canada and the Association of Canadian Community Colleges, to recruit Energy Innovators and to stimulate energy-saving activities.

After becoming members, Energy Innovator organizations can access a variety of tools and services from the EII:

- financial incentives;
- help in developing energy management plans;
- access to technical expertise and audits;
- advice on alternative financing options for retrofit projects;
- information on developments in energy-efficient technologies;
- sector-specific workshops and seminars;
- sector-specific benchmarking and best-practices guides;
- newsletters, success stories and other publications; and
- opportunities to promote achievements of member organizations.

Since 1998, the EII Pilot Retrofit Incentive has encouraged commercial and institutional organizations to initiate or expand the scope of new energy efficiency projects. Funding is available for up to 25 percent of the costs of a defined pilot project – up to $250,000 – if the eligible Energy Innovator organization agrees to replicate the measures in at least 25 percent of its other facilities.

Achievements 2000–2001

- At the end of the fiscal year, the EII Pilot Retrofit Incentive was extended for an additional three years with plans to expand the funding options in 2001–2002 through the *Government of Canada Action Plan 2000 on Climate Change*.
- More than 250 participants in the "Dollars to $ense" workshops were from the commercial and institutional sectors.

Federal Buildings Initiative

The Government of Canada is taking stock of the state of energy efficiency in its federal operations. More than 80 percent of the total energy demand in the federal government is used in building operations. The Government of Canada owns or leases about 25 million m^2 of floor space, with 90 percent of it concentrated in five departments.

Since its announcement in 1991, the Federal Buildings Initiative has been highly effective in promoting energy efficiency implementation strategies for federally owned and/or occupied facilities and buildings. It offers comprehensive turnkey solutions for federal departments, agencies and Crown corporations to undertake energy efficiency improvements without using their own capital funds. By partnering with a pre-qualified energy management firm, a department can benefit from services such as third-party, private-sector financing; project management; commissioning and construction; comprehensive training; and performance guarantees.

Achievements 2000–2001

- The Parks Canada Agency has awarded an energy management contract to retrofit and upgrade its facilities in Banff National Park. This 10-year contract, with an estimated value of $500,000 to $900,000, is expected to generate annual energy and water savings of $50,000 to $100,000. GHG emissions will also be reduced by more than 500 tonnes per year.
- The RCMP has negotiated its first energy management contract for its "D" Division Headquarters in Winnipeg, Manitoba. Planned energy savings will reduce GHG emissions by 157 tonnes per year. This $900,000 project will be paid for from savings over 10 years.
- The Department of National Defence, Public Works and Government Services Canada and the National Research Council of Canada continue to promote energy efficiency improvements in their facilities throughout the country:
  - Fifteen Canadian Forces Base projects – resulting in more than $90 million in investments and $10.5 million in annual savings – are at various stages of implementation.
  - Public Works and Government Services Canada has awarded some 32 energy management contracts, involving more than $40 million in investments. These projects are expected to generate more than $6.3 million in annual energy savings.
  - The National Research Council of Canada has implemented improvement projects at its Montreal Road Campus in Ottawa, Ontario, and Industrial Materials Institute in Montréal, Quebec. The measures – a total investment of more than $1.4 million – include the installation of a cogeneration chiller, a high-efficiency boiler and upgrades to lighting. Annual energy savings are expected to reach $289,500.

Federal Industrial Boiler Program

The FIBP assists its clients in increasing energy efficiency, reducing nitrogen oxide (NO_X) emissions and extending the useful life of existing heating and cooling systems and auxiliary equipment. The FIBP encourages its clients to consider energy-efficient and environmentally responsible technologies when replacing or modifying industrial heating and cooling plants.

FIBP services are available to all federal departments and agencies, Crown corporations, provincial and municipal departments and the private sector. The Government of Canada owns 52 central heating plants, housing more than 270 boilers that consume more than 8000 terajoules of fuel annually. Services delivered under the FIBP help government departments and other clients adopt heating technologies that could reduce NO_X emissions by 50 percent, increase energy efficiency by up to 15 percent, and reduce operating costs by 20 percent, compared with conventional practices.

Achievements 2000–2001

- On behalf of the Correctional Service of Canada (CSC), NRCan has analysed NO_X emissions at most CSC central heating plants across the country. The results at the Leclerc Institution in Laval, Quebec, indicate that the equipment is approaching the end of its life cycle. The FIBP developed a plan to replace three of the four boilers with high-efficiency boilers and low-NO_X burners and provide a new control system. These will reduce NO_X emissions to the level specified in the guidelines of the Canadian Council of Ministers of the Environment and reduce energy consumption.
- NRCan conducted a site survey of the mechanical and electrical systems at the Canadian embassies in Riyadh, Saudi Arabia, and Tehran, Iran, and developed recommendations for improvements. Since 1997, NRCan has provided the Department of Foreign Affairs and International Trade with technical and project management services as it retrofits and upgrades its embassies around the world.
- NRCan has improved its control systems and central heating plants at its facility in Bells Corners, Ontario. The results will ensure a safe and efficient work environment.
- NRCan has conducted training sessions for heating plant operators in Russia and Canada. The training sessions were based on the guide *Efficiency Improvement and Emissions Reduction for Boilers and Heaters*, prepared and published by NRCan and funded jointly by the Ontario Ministry of the Environment, Enbridge Consumers Gas and Union Gas.

Commercial and Institutional Sector: Existing Buildings

Progress Indicators

As of March 2001, more than 600 commercial and institutional organizations had been recruited as Energy Innovators. These Energy Innovators represent approximately 26.9 percent ($2.5 billion) of the total energy bill of the commercial and institutional sector in Canada.

FIGURE 21
Recruitment of Energy Innovators (Commercial and Institutional), 1992–1993 to 2000–2001

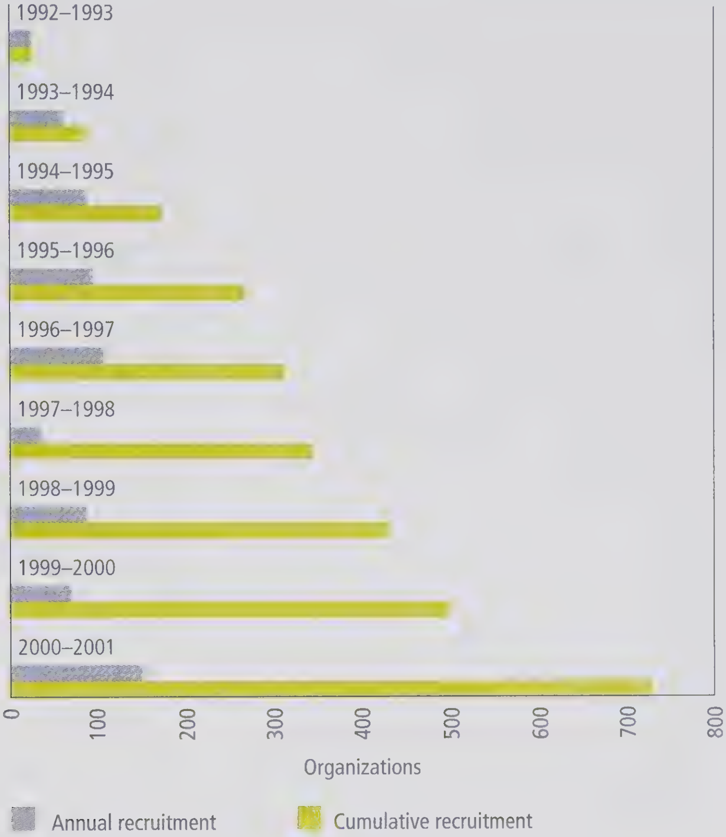


FIGURE 22
Percentage of Commercial and Institutional Sectors Recruited

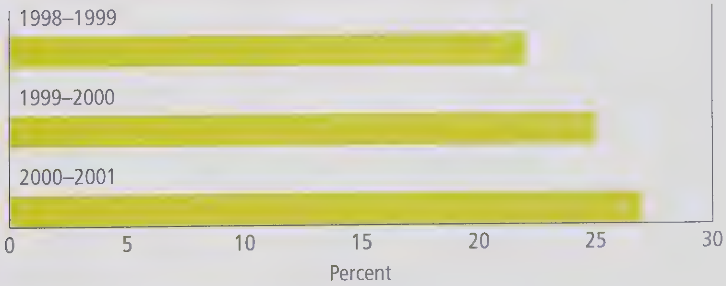
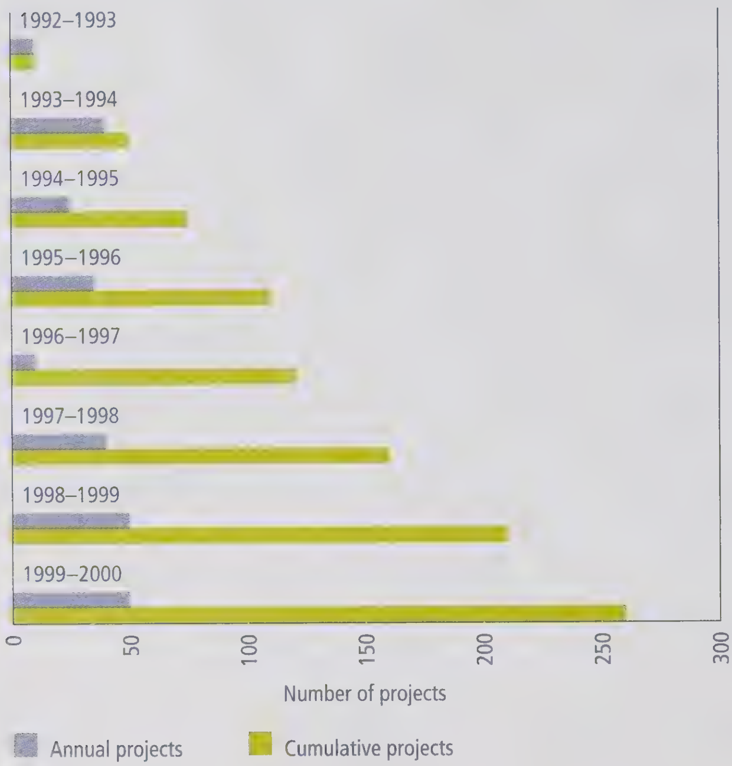


TABLE 2
Energy Innovators Pilot Retrofit Incentive, 1998–1999 to 2000–2001

	1998–2001
Federal incentives	$8.8 million
Private sector investment	$147.6 million
Energy savings	$14.1 million

The investment and savings are estimated and include both pilot and replication.

FIGURE 23
Energy-Saving Projects Under the Energy Innovators Initiative, 1992–1993 to 1999–2000



Progress Indicators (continued)

In its first three years, the EII Pilot Retrofit Incentive approved 52 projects representing more than 8 million m^2 of space. These projects will reduce energy costs by $21 million and reduce energy consumption by 1.5 million gigajoules annually (or 20 percent on average), based on a total investment of $208 million ($8.8 million from the incentive).

Progress Indicators (continued)

FIBP projects implemented in 1999–2000 saved 93 terajoules per year (see Figure 25). Since 1991–1992, the energy savings from this program have risen to 597 terajoules per year, and the cumulative energy savings since the program began are about 2.5 petajoules.

FIGURE 24
Federal Buildings Initiative Investment and Energy Savings

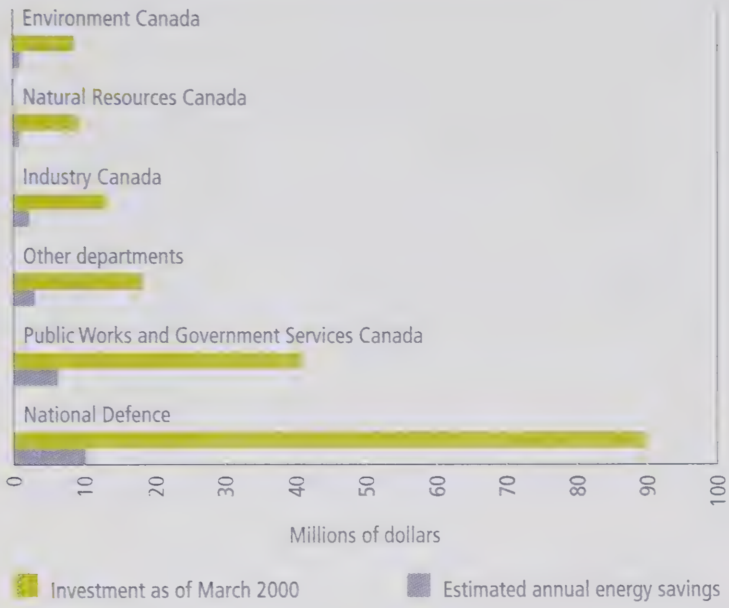
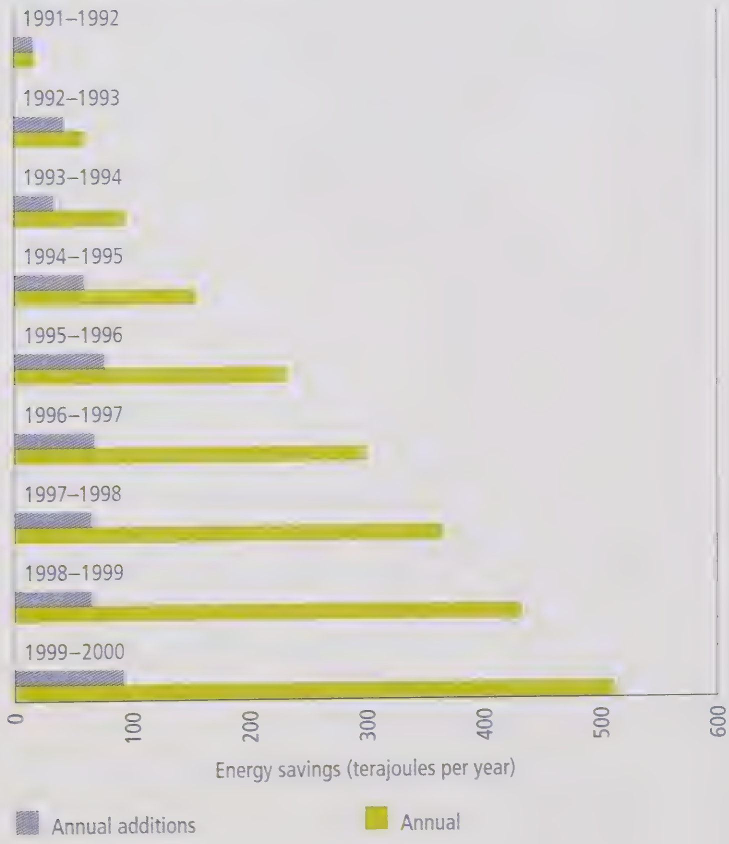


FIGURE 25
Energy Savings from the Federal Industrial Boiler Program, 1991–1992 to 1999–2000



Equipment

NRCan uses the following initiatives to encourage the development and use of energy-efficient equipment in commercial and institutional buildings:

- *Energy Efficiency Regulations*; and
- the Buildings Program.

Energy Efficiency Regulations

Under the authority of the *Energy Efficiency Act*, NRCan sets *Energy Efficiency Regulations* for selected types of energy-using equipment to eliminate less energy-efficient products from the market. The Regulations prohibit imports of or interprovincial trade in prescribed products that fail to meet minimum energy performance levels. The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. NRCan funds and participates in nationally accredited standards-writing committees administered by CSA International to foster the development of these standards.

Buildings Program

The Buildings Program develops and transfers refrigeration and intelligent buildings technologies in partnership with industry and provides technical support for the dissemination of ground-source heat pumps.

Achievements 2000–2001

- The Programme d'intervention en réfrigération dans les arénas du Québec in partnership with l'Agence de l'efficacité énergétique du Québec, l'Association des arénas du Québec, Hydro-Québec and Gaz Métropolitain completed an evaluation of Quebec's arenas. The evaluation showed potential energy savings of 270 GWh and GHG emissions reductions of 80 kilotonnes CO_2 equivalent per year.
- NRCan began testing the Diagnostic Agent for Building Operators (DABO), as part of its Buildings Program, in one of its buildings. This first version is a computerized tool that allows the detection and diagnosis of mechanical system defects in buildings. It is now being used to improve control of the ventilation system at Montréal-Dorval Airport.
- NRCan signed an agreement with Provigo Inc./Loblaw Companies Limited to undertake a pre-feasibility study of advanced refrigeration, heating, cooling and dehumidification technologies for a green supermarket. The study will examine how to reduce energy loads and leaks of synthetic refrigerants.
- NRCan received project approval from Precarn Incorporated to develop an intelligent building controller with fault detection and diagnosis and an energy manager for commercial buildings. A major Canadian control manufacturer, a university, a research centre and Public Works and Government Services Canada will be NRCan's partners in the project.

Commercial and Institutional Sector: Equipment

Progress Indicators

The first *Energy Efficiency Regulations*, which took effect in February 1995, covered two commercial energy-using products: electric motors and fluorescent lamp ballasts. The first amendment passed in November 1995 included minimum performance requirements for fluorescent lamps, which took effect on February 1, 1996, and for incandescent reflector lamps, which took effect on April 1, 1996. The fluorescent lamp regulations reduced the annual energy use by 20 percent for the 2.4-m (8-ft.), high-output lamp and by 15 percent for the 1.2 m (4-ft.), medium bi-pin lamp, two of the most popular fluorescent lamps (see Figure 26).

In November 1997, the second amendment to the *Energy Efficiency Regulations* was passed. This amendment included stronger regulations for motors in the commercial and industrial sectors. This regulation will lead to annual energy savings of 4.6 petajoules in 2005 (see Figure 27).

FIGURE 26
Influence of Regulations on Energy Use of Two Fluorescent Lamp Types, 1996

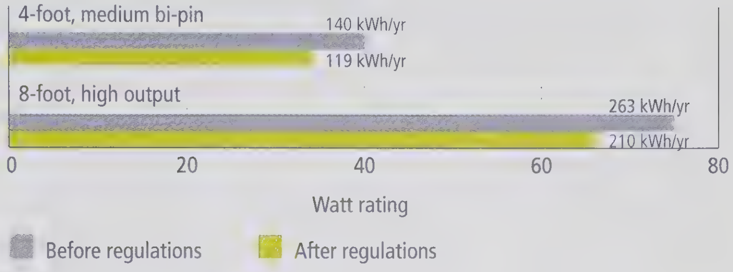


TABLE 3
Savings Arising from Canadian Energy Efficiency Lighting Regulations

Annual sales of lamps affected by regulations	$33 million
Estimated direct savings of electricity used for lighting in 2000	39 petajoules
Estimated net energy savings in 2000*	10 petajoules
Estimated net reduction in GHG emissions in 2000	5.5 megatonnes

* The estimate of net energy savings is lower than the estimate of direct savings of electricity because the direct savings of electricity are partially offset by an increase in space-heating demand required because more efficient lighting emits less heat. When this effect is taken into account, estimated energy savings are less. The net effect varies by region and building.

FIGURE 27
Energy Savings from Motor Regulations, 2000 to 2020

Chapter 5
Industrial Sector

Energy Use and Greenhouse Gas Emmissions

The industrial sector includes forestry, construction and mining, as well as all manufacturing. This sector uses energy in industrial processes as a source of motive power, to produce heat or to generate steam. Overall, industrial energy demand accounts for 39.2 percent (3069 petajoules) of secondary energy use and 33.6 percent (151 megatonnes) of greenhouse gas (GHG) emissions.

Within the industrial sector, energy is consumed primarily in the petroleum refining, iron and steel, upstream mining, aluminum, organic chemicals, pulp and newsprint and other paper industries. Together, these sectors accounted for 64.5 percent of total industrial energy demand in 2000 (see Figure 28).

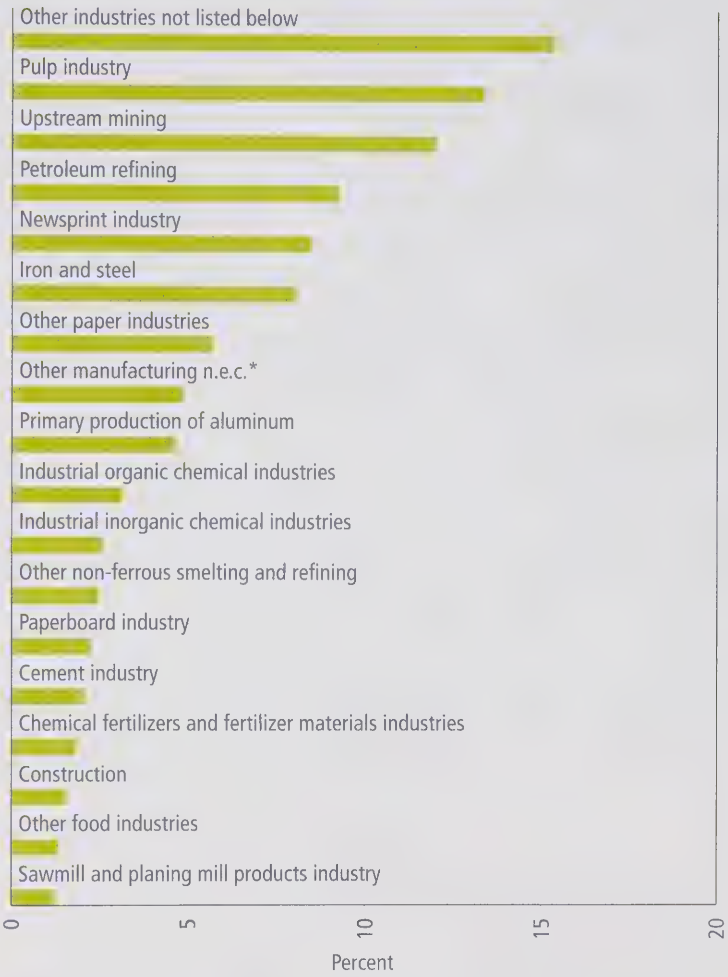
In most industries, energy purchases account for only a small proportion of total expenditures. However, for some relatively energy-intensive industries – lime, cement, magnesium and aluminum – this share is higher than 15.0 percent (see Figure 29).

After decreasing slightly from 1990 to 1991 as a result of the recession, industrial energy use had increased by about 16.3 percent (449 petajoules) by 2000 (from 2755 to 3204 petajoules) (see Figure 30). The main factor that increases industrial energy use is activity:

- *activity* – increases in physical industrial output, gross output and gross domestic product (GDP) contributed to an increase in energy use of 36.5 percent (1005 petajoules); and
- *structure* – the change in the mix of activity toward less energy-intensive industries (such as electric and electronic) resulted in an 11.5-percent decrease in energy use (317 petajoules).

If only these two factors had been in effect, industrial energy use would have increased by 25.0 percent (688 petajoules). However, improvements in energy efficiency worked to decrease energy use by 8.7 percent

FIGURE 28
Industrial Energy Use by Subsector, 2000



*n.e.c. = not elsewhere classified.

(239 petajoules). As a result, energy use increased by only 16.3 percent. This change in energy use during 1990 to 2000 and the energy savings due to energy efficiency are shown in Figure 30.

Whereas energy use between 1990 and 2000 increased by 16.3 percent, industrial GHG emissions increased by only 12.9 percent.

NRCan delivers initiatives to increase energy efficiency in the following subsectors of the industrial sector:

- industrial processes and technologies; and
- equipment.

FIGURE 29
Cost of Energy to Industry as Percentage of Total Production Cost, 1998

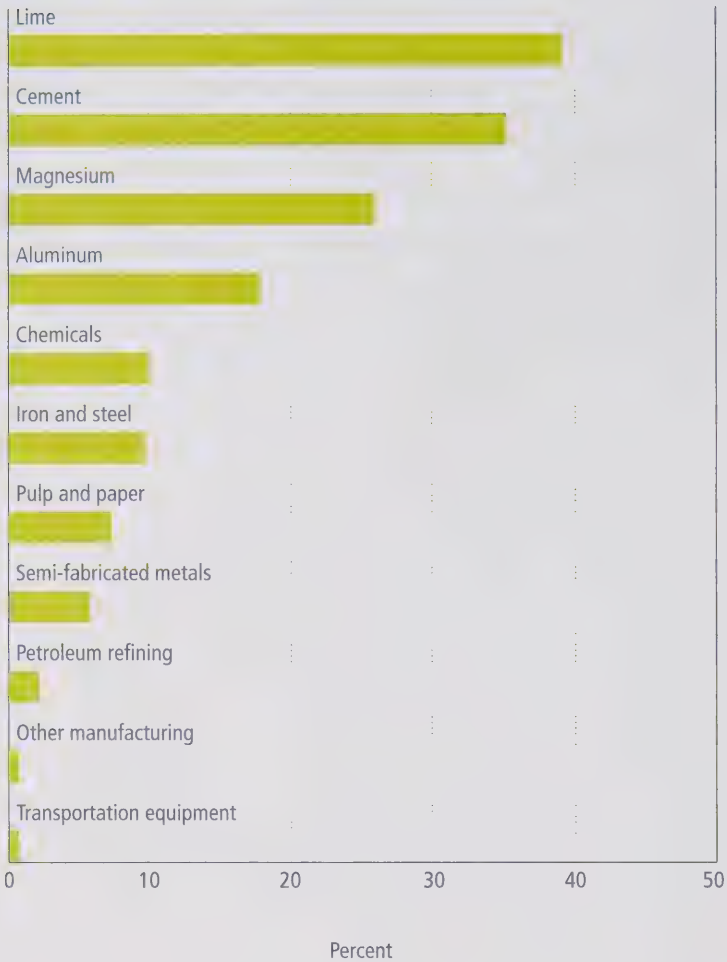
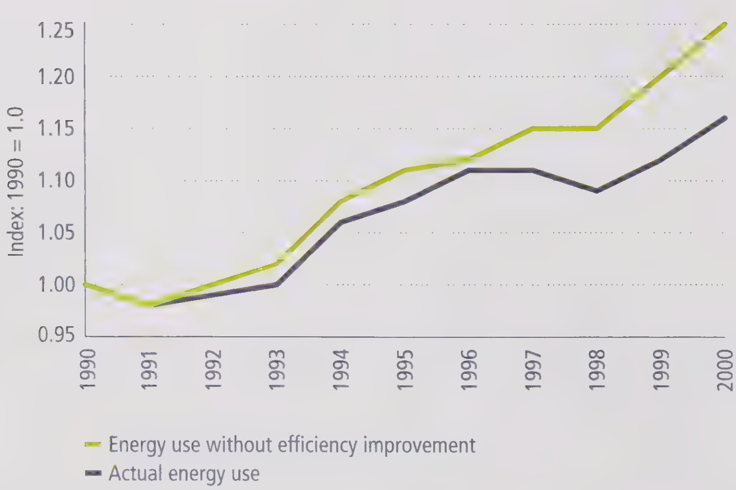


FIGURE 30
Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000



Industrial Processes and Technologies

NRCan promotes energy efficiency in the industrial sector through the following initiatives:

- Industrial Energy Efficiency;
- the Industry Energy Research and Development Program;
- the Emerging Technologies Program;
- the Industrial Process Integration Program;
- the Industrial Process Engineering Program;
- the Advanced Combustion Technologies Program;
- the Energy Technologies for High Temperature Processes Group;
- the Processing and Environmental Catalysis Group; and
- the Minerals and Metals Technologies Initiative.

NRCan also provides technical advice to the Canada Customs and Revenue Agency on applications by companies to depreciate their assets under Class 43.1 of the *Income Tax Act*. This class provides an accelerated capital cost allowance to manufacturing and process industries for certain types of energy-efficient or renewable energy equipment. NRCan advises on whether the equipment in question meets or would meet the technical conditions spelled out in regulations.

Industrial Energy Efficiency

The IEE provides a framework for a voluntary industry-government alliance to achieve greater energy efficiency in Canada's manufacturing and mining sectors. It uses a two-tiered approach – it operates at the industrial sector level through the Canadian Industry Program for Energy Conservation (CIPEC) and at the company level through the Industrial Energy Innovators Initiative (IEII).

CIPEC, which celebrated its 25th anniversary in 2000, has task forces for a majority of industrial sectors to determine their potential for energy efficiency improvements, establish targets for improvement, create action plans for reaching these targets, and track and report on progress. These task forces also provide a forum for stakeholders to identify common needs in areas such as energy management planning, technical information, financing, training and employee awareness. NRCan works with the task forces to develop appropriate services to satisfy these needs.

Once CIPEC task forces establish targets and action plans, the IEII helps to transform these commitments into company action. To become an Industrial Energy Innovator, a company commits to

- develop and implement a target and action plan for energy efficiency improvement;
- appoint a corporate energy efficiency champion; and
- track its improvements in energy efficiency and report on them annually against its action plan.

NRCan provides Innovators with tools and services such as employee awareness kits, best-practices guides, technical information and workshops on energy management.

CIPEC encourages Industrial Energy Innovators to register their action plans with VCR Inc., which provides a public record of an organization's commitments, action plans and results on energy efficiency and GHG emissions.

Achievements 2000–2001 – CIPEC

- There has been an increase in the number of industrial sectors represented by CIPEC. Four new trade associations made a formal commitment to join the CIPEC network, increasing the total number of associations participating to 38.
- Twenty-four issues of *Heads Up CIPEC*, a newsletter devoted to CIPEC events and industrial energy efficiency success stories, were published during 2000–2001, reaching an audience of more than 2200 readers per issue.

Achievements 2000–2001 – Industrial Energy Innovators

- By March 31, 2001, NRCan had signed on 51 more companies to be Innovators, bringing the total number of Innovators to 295. In addition, the program recruited 56 percent more participants for its "Dollars to $ense" workshops than the previous year – raising the number of industrial participants to 270 for 2000–2001.
- NRCan employees participated in community and employee awareness events at four Innovator facilities in Ontario and Quebec. These events, which were attended by more than 25 000 people, provided NRCan with an opportunity to promote its industrial and consumer energy efficiency products and services.

Industry Energy Research and Development Program

The Industry Energy Research and Development Program encourages and supports the development and application of leading-edge, energy-efficient and environmentally responsible processes, products, systems and equipment in industry. Financial support is provided for commercially confidential applied R&D activities, which is repayable if the project is commercially successful. Program clients from all industrial sectors range from small- and medium-sized companies to multinational corporations.

Achievements 2000–2001

- NRCan is supporting la Société des technologies de l'aluminium (STAS ltée), of Chicoutimi, Quebec, to design, develop and demonstrate a new system to service aluminum-reduction cells. The new system will save energy and reduce GHG emissions by minimizing process interruption through computer-assisted anode replacement, which is currently done manually.
- Sorentec inc. of Québec is developing, with NRCan financial assistance, new and highly energy-efficient refrigeration systems for commercial kitchens.

- NRCan is helping Energen Industries Ltée of Saint-Romuald, Quebec, in its development of an instantaneous hot-water heater. This device will address shortcomings of other tankless heaters, such as corrosion, fouling, safety and overall reliability. It will provide an energy-efficient option for hot-water availability at distant locations from a main hot-water source.
- NRCan provided financial support to M&I Heat Transfer Products Ltd. of Mississauga, Ontario, for the development of more efficient products used for heating, ventilating and air-conditioning (HVAC) systems and for gas turbine power generation systems. M&I has utilized advanced, innovative aerodynamic science and technologies to achieve increased energy efficiencies. M&I has secured seven patents and has four more pending.

Emerging Technologies Program

The Emerging Technologies Program supports the identification and demonstration of new and emerging energy-efficient technologies. Projects are co-managed and cost-shared with industry and other stakeholders, such as gas and electric utilities, other governments and equipment manufacturers.

Financial support is provided for the development and testing of pilot plants, prototypes and full-scale field trials to evaluate operating performance, energy efficiency and environmental impacts. NRCan's financial support is repayable from any cost savings or revenues realized from a project. Program clients from across Canada represent a wide range of industrial sectors and company sizes.

Achievements 2000–2001

- NRCan supported the design, construction and operation of a 250-kW estimated pre-commercial prototype solid oxide fuel cell combined heat and power plant at Kinectrics Inc. (formerly Ontario Power Technologies of Toronto, Ontario). When compared with a coal-fired power plant, the combined heat and power plant could reduce CO_2 emissions by 57 percent.
- NRCan is providing support to Union Gas Limited and a number of industrial partners to examine advanced technologies to convert key production equipment to use or co-fire natural gas instead of using coal, coke and/or heavy oil. Five different technologies will be tested through innovative computer simulation techniques, many of which were developed by NRCan scientists, and then pilot tested to achieve maximum cost-effective performance. The technologies being tested could potentially reduce CO_2 emissions by 63 000 tonnes per year.
- NRCan is helping Climatisation Réfrigération P.M.G. Inc. of Alma, Quebec, to develop and demonstrate a novel system for the efficient heating of greenhouses. The system utilizes shallow-depth ground-heat collectors and transfers the heat into the greenhouse.
- NRCan is working with MAKA Innovation technologique inc. of Montréal, Quebec, by financially supporting field trials of drag-reducing fins installed at the rear of tractor-trailers, reducing aerodynamic drag by 5 percent. Dubbed "BoatTails," their potential fuel savings are in the order of 1.3 litre/100 km per trailer.

Industrial Process Integration Program

The Industrial Process Integration Program supports the development and adoption of process integration in various industries. The program focuses on the following:

- combined heat and power optimization methodologies;
- total-site optimization methodologies;
- batch processes optimization methodologies;
- water-pinch optimization methodologies in the agri-food, pulp and paper and textile industries; and
- building international-calibre Canadian capacity in process integration.

Achievements 2000–2001

- NRCan completed a process integration study at the Smurfit-Stone Container Corporation paperboard mill in La Tuque, Quebec, that identified energy savings opportunities representing a 15-percent reduction in fossil fuel purchases and a reduction in CO_2 emissions of 50 000 tonnes per year. The mill has already achieved more than half of the energy reduction potential as a result of implementing some of the identified heat recovery projects.
- NRCan initiated a process integration study to identify energy savings and waste-water reduction opportunities at the Norampac Inc. paperboard mill in Red Rock, Ontario. The technical partners, Cascades Research Centre and Cascades Engineering Group, are providing process and engineering expertise.
- NRCan, the Agence de l'efficacité énergétique and a textile dyeing company have co-operated to demonstrate the benefits of using process integration methods to reduce energy consumption in a textile dye house in Montréal, Quebec. Estimated savings are in the order of $1 million per year (40 percent of actual energy consumption) with a payback period of eight months. The project will lead to a CO_2 emissions reduction of 6.4 kilotonnes per year.

Industrial Process Engineering Program

The mandate of the Industrial Process Engineering Program is to enable industry to continuously improve its energy efficiency and productivity while decreasing GHGs and other pollutant emissions. This is achieved by performing leveraged R&D, introducing novel technologies, performing incremental improvements, performing industrial audits and disseminating technical information. The program focuses on industrial drying and catalytic flow reversal reactor technology.

Achievements 2000–2001

- A memorandum of understanding (MOU) was signed during the Team Canada mission to China in February 2001, regarding the introduction of a new Canadian climate change technology developed at NRCan called CH4MIN. This technology destroys methane emissions from coal mine ventilation air while producing useful energy. China is the world's biggest coal producer, and these emissions add up to more than 100 million tonnes of CO_2 equivalent per year and to more than 250 million tonnes of CO_2 equivalent per year worldwide. It is estimated that the CH4MIN technology could treat up to 50 percent of China's emissions, resulting in an emissions reduction of 50 million tonnes of CO_2 equivalent per year. The MOU will assure Chinese assistance to a Canadian licensee in disseminating the technology in China. Other coal-producing countries have expressed interest in the CH4MIN technology, including the U.S., Poland, Bulgaria, the Ukraine, India and the Czech Republic.
- NRCan, along with members of Montréal's university, industrial and research community, helped organize the 50th Canadian Chemical Engineering Conference in Montréal, Quebec, which attracted 1200 participants from Canada and around the world. A prize for the best student technical paper went to a student from the Université de Sherbrooke who conducted work on CH4MIN.
- NRCan and the Governors' Foundation of Agriculture and Agri-food Canada's Food Research and Development Centre jointly organized "Advanced Drying Technologies for Food Industries," a symposium held in 2000. NRCan scientists acted as co-chairs and co-organizers, delivering lectures on energy aspects, product contamination and novel drying technologies, including original NRCan designs for the pulsed fluid bed dryer and the jet spouted bed dryer. The symposium targeted technologies for enhancing products, energy conservation and environmental

protection while opening new avenues for product innovation. It was well attended by technical and management personnel from leading Canadian food industry organizations and by internationally recognized speakers from Canada, Japan, Norway, Finland and Kuwait. The symposium concluded with a demonstration of dryers and ancillary equipment at NRCan's facility in Varennes, Quebec. As a result of this event, various international and Canadian institutions expressed interest in collaborating on R&D projects and in licensing NRCan's drying technologies.

- NRCan initiated the Industrial Drying Energy Efficiency Program. This program consists of evaluating the energy consumption, the drying technology performance, and opportunities for improvement in four energy-intensive sectors (wood, textile, food and chemicals). The wood sector is the first to be addressed because of its importance in Canadian industry, with sales of $8 billion per year and an energy consumption of 120 petajoules per year. The uniformity of the dryers used throughout the industry will allow easy duplication of any improvement measures. This project consists of performing a technical market study and energy audits around representative dryers, identifying short- and long-term technical and operating improvements, training consultants and operators, implementing energy-saving measures and measuring their effectiveness, and disseminating the information throughout the sector. A strong partnership between governmental agencies, associations, the industry, kiln manufacturers and NRCan has been established in order to carry out the program.

Advanced Combustion Technologies Program

The Advanced Combustion Technologies Program helps industry develop cleaner, more energy-efficient combustion processes, with lower emissions of acid-rain precursors, GHGs, particulates and identified priority substances – trace elements and organic compounds. The program's research focuses on optimizing the performance of stationary equipment and developing and evaluating new products, fuels and retrofit technologies, using conventional fuels – oil, coal and natural gas – and biomass and specialty fuels.

The program's facilities include seven pilot-scale industrial boilers and furnaces, laboratories for equipment testing, laser diagnostics and fuel characterization, emissions-monitoring capabilities and strong computer-modelling capabilities.

The program serves clients from a variety of sectors, including electrical utilities and other operators of stationary combustion facilities; oil, coal and natural gas producers; pulp and paper producers; combustion equipment manufacturers; software developers; industry associations; federal and provincial government departments and standards-writing organizations.

Achievements 2000–2001

- NRCan carried out verification tests on a patented Chinese technology known as "One Furnace, Two Functions" at the department's vertical combustor pilot plant. This technology improves the utilization of ashes from a coal-fired power plant by adding an ash-modification component that simultaneously allows the boiler to produce steam and high-quality cement clinker. It might also improve combustion performance by lowering the proportion of unburnt carbon in ashes and reducing the emission of sulphur dioxide (SO_2).
- NRCan provided technical assistance on the design, construction and operation of the first prototype of a 300-kW straw gasifier, which will be used for space heating at a manufacturing plant in Arborg, Manitoba. The unit was designed to operate on flax and wheat straw, both of which are readily available in Manitoba and Saskatchewan. Work began on a patent application for the feed system.
- NRCan developed a proposal to demonstrate an industrial-scale gasification plant in rural China that would supply the energy needs of 2000 families and selected small industries. The project would examine the feasibility of using

rice straw and other GHG-neutral waste biomass materials and assess the feasibility of producing fertilizer and bio-oil in addition to fuel gas, steam and electricity.

- NRCan presented a series of technical seminars on oil-heating systems to more than 250 members of the Canadian Oil Heat Association. The seminars concentrated on advances in oil-heating technology and how to make existing oil-heating installations more efficient and environmentally friendly.

Energy Technologies for High Temperature Processes Group

The Energy Technologies for High Temperature Processes Group investigates technologies and develops knowledge to ensure the sustainability of Canada's coal, carbon and metallurgical industries. The group has expertise in carbonization, combustion, agglomeration, thermal rheology petrography and environmental and carbon science technologies to address energy efficiency, GHG reduction and related needs of industry. Key areas include alternative iron-making technology, fuel products, iron and steel process efficiency, standardization and analysis of emissions.

Achievements in 2000–2001

- NRCan conducted two studies on improving iron-making technologies. One study identified alternatives to blast furnace iron-making technology that can reduce energy consumption and improve GHG emissions from Canadian industry. NRCan also completed a research project that investigates methods to increase the life of coke oven batteries that will result in improved energy efficiency and reduced emissions.
- NRCan modified its pulverized coal injection facility and investigated the combustibility of the co-injection of coal and natural gas in a simulated blast furnace test facility. NRCan also used the facility for an investigation with the Canadian Carbonization Research Association to assess the combustibility of western Canadian coals when co-fired with natural gas.
- Phase III of a joint project between Environment Canada and NRCan on the study of atmospheric aerosols and engine particulates has been completed. NRCan provided a detailed chemical analysis of the soluble organic fraction of particulates with the goal of determining the sources of contaminants found in atmospheric aerosols. The results show incontrovertibly that these compounds find their way into engine particulates exclusively from the lubricating oils. NRCan's quantitative data on the abundance of these biomarkers helps to fill in important missing pieces of particulate source apportionment.
- NRCan conducted work with the Canadian High Commission to India to assess the potential of using western Canadian coals in the Steel Authority of India Limited's (SAIL's) coking coal blends. SAIL currently uses about 50-percent indigenous coal and 50-percent Australian coal for its four steel-making operations. SAIL has requested that NRCan use its coking models to predict the quality of coke that could be produced from blends of different Canadian coals in several Indian coking blends, improving energy efficiency.

Processing and Environmental Catalysis Program

The Processing and Environmental Catalysis Program seeks to solve industrial process problems and research areas with high potential for significant environmental and economic benefits. The program's facilities, including semi-pilot scale plants, are used for process testing and evaluating novel concepts in chemical and energy conversion. The program targets energy efficiency in chemical processing and works with consortia to

- develop catalytic systems for nitrogen oxide (NO_X) removal from diesel engine emissions;
- convert natural gas to liquid fuels, fuel components, petrochemicals and synthesis gas;

- develop a process to derive high-quality transportation fuels and cetane enhancers from used motor oil and from biomass-derived oils;
- convert low-grade heat to electricity for increased industrial energy efficiency; and
- develop high-temperature ceramic membranes for hydrogen or CO_2 separation and purification.

Clients include oil and gas companies, petrochemical companies, original engine manufacturers, waste oil renderers and specialty ceramic manufacturers.

Achievements 2000–2001

- NRCan developed a methodology for preparing high-performance dense-phase ceramic membranes for hydrogen separation, which has achieved the highest reported performance in terms of permeation rates and separation. This development has the potential for a range of applications in the petrochemical and fuel cell industry. Hydrogen separation at high temperatures saves process energy because it does not require cooling prior to separation. NRCan is now seeking a Canadian industrial champion to demonstrate and commercialize the technology.
- NRCan is in the process of patenting a novel catalyst for the production of hydrogen and carbon monoxide (synthesis gas) from natural gas. The catalyst is coke-resistant, which allows operation over a long duration. The catalyst technology along with the membrane technology offers a more energy-efficient process for synthesis gas or hydrogen from natural gas.
- NRCan improved, by an order of magnitude, the electric output of a prototype device that uses a novel concept to convert low-grade waste heat to electricity through pyro-electric conversion. The technology will increase the energy efficiency of industrial processes by exploiting the energy contained in low-temperature process streams that are currently discarded. Estimates show the potential for a 10-percent reduction in energy consumption for a typical pulp and paper operation using this new technology. NRCan is seeking sponsorship to further develop this new generation technology that targets energy efficiency.
- NRCan developed a low-cost method for blending ethanol with diesel that would allow the introduction of ethanol to the diesel market. The process is being patented.

Minerals and Metals Technologies Initiative

The Minerals and Metals Technologies Initiative helps Canada's minerals and metals industries improve energy efficiency and reduce energy costs. Many of the initiative's research projects involve increasing the use of recyclable materials or improving or eliminating industrial processes that use excessive energy. Activities with industry include technology development and pilot-scale demonstration projects that focus on information dissemination, technology transfer and product commercialization. Partners include Canadian companies – especially foundries – provincial governments, energy utilities and industrial, trade and standards associations.

Achievements 2000–2001

- NRCan researchers have led a consortium to develop the CANDRILL, an innovative rockdrill that is powered by a high-pressure water system rather than compressed air. This new rockdrill and the system that runs it will increase energy efficiency from 30 to 50 percent and substantially reduce several of the hazards that miners face. The CANDRILL is now in a final optimization stage, with NRCan's efforts focused on working with regulators to develop new Canadian standards for the use of electro-hydraulics. Testing indicates that, compared with its compressed-air counterpart, the new rockdrill drills holes twice as fast, offers reduced vibration, dust and noise (15 decibels quieter), weighs less (14 kg lighter) and eliminates oil mist emissions.

- The North American consortium to replace diesel with hydrogen fuel cells as the energy source for underground mine production vehicles is continuing to advance successfully with NRCan as one of its champions. Fuel cell applications to underground mine equipment will lower production costs through reduced ventilation (approximate reductions of 35 percent in natural gas use and 12 percent in electric consumption) and reduce GHG emissions of about 1.0 million tonnes per year. The first of several of this consortium's research projects was the Canadian-built mine locomotive – the world's first fuel cell underground vehicle. During the past year, work was completed to equip the locomotive with a fully functional hydrogen fuel cell power plant, and it was displayed at the world's largest mining equipment show in Las Vegas, Nevada. Extensive scientific, safety and productivity tests will then be performed by NRCan at its experimental mine and at two operating Canadian mines.
- NRCan's International Centre for Sustainable Development of Cement and Concrete (ICON) continued to promote the use of high-volume fly ash (HVFA) concrete. Fly ash, a by-product of burning coal in power plants that normally goes to landfill, can be substituted for a portion of the Portland cement in concrete, thereby increasing concrete durability, saving energy and reducing GHG emissions (manufacturing cement for concrete releases one tonne of CO_2 per tonne of cement). The technology to create EcoSmart™ concrete – pioneered at NRCan – replaces approximately 50 percent of the cementing materials with fly ash, resulting in HVFA concrete. During 2000–2001, NRCan's collaboration with partners resulted in the use of EcoSmart™ concrete in several buildings in the Greater Vancouver Regional District, such as the Liu Centre for the Study of Global Issues on the campus of the University of British Columbia, which is the first building in British Columbia to use HVFA concrete.
- A key factor in improving vehicle efficiency is the vehicle's weight – for every 10-percent reduction in vehicle weight, there is a 6- to 8-percent improvement in fuel consumption. NRCan has continued to provide secretariat support to an industry steering committee that is leading the Canadian Lightweight Materials Research Initiative, a government-industry partnership to produce advanced, lightweight components for vehicles through value-added processing of materials. With industry targets of up to 40-percent weight reduction and a North American market of 12 million vehicles per year, there is large potential for increased fuel economy. Research is performed in advanced manufacturing, vehicle design, life-cycle analyses, coatings, new alloys and plastics, parts manufacturing and vehicle assembly. For example, during the past year, NRCan determined that it is technically and economically feasible to use an NRCan-developed lightweight metal-matrix composite material in heavy-duty vehicle brake drums and rotors.

Progress Indicators

FIGURE 31
Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 2000

*n.e.c. = not elsewhere classified.

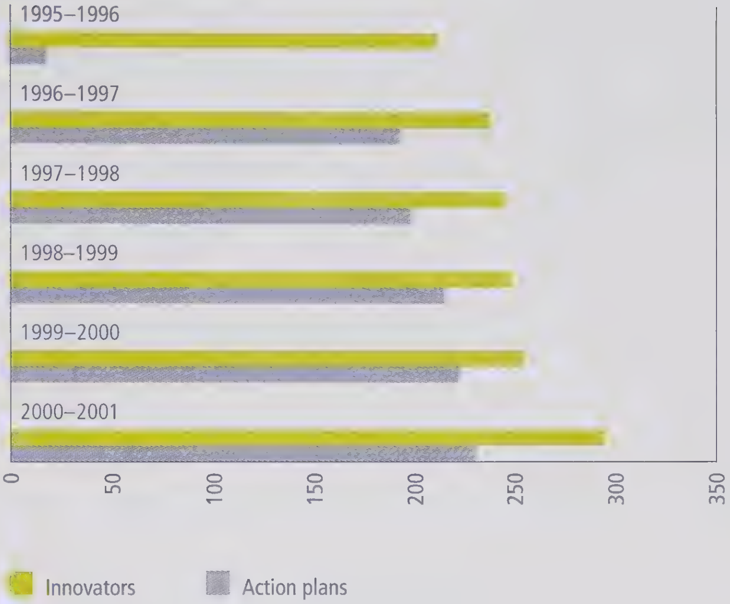
Progress Indicators (continued)

From 1990 to 2000, 31 of the 34 industrial sectors improved their energy intensity. The most notable intensity improvements were made by the electric and electronic, glass, gold, rubber and beverage sectors, which realized efficiency gains of 41 to 75 percent (see Figure 31).

CIPEC reports on approximately 90 percent of total industrial energy demand through 21 task forces. Although not all companies in every industrial subsector are aware of CIPEC, each task force reports progress for its entire subsector, as defined by Statistics Canada's Standard Industrial Classification (SIC) system. Data from the Industrial Consumers of Energy (ICE) Survey enable the CIPEC task forces to compare their performance with their energy efficiency improvement targets. Where possible, CIPEC measures energy efficiency as energy use per physical unit of production. Where physical denominators are not available, an economic denominator is used.

Most task forces have committed to energy efficiency improvements of 1 percent per year from 1990 to 2005. Exceptions are breweries (3.0 percent), textiles (2.0 percent), cement (0.7 percent) and electric and electronic (1.25 percent). During 1990–1999, the energy intensity of the then 21 CIPEC task forces improved on average by 2.0 percent per year. By March 2000, the IEE Initiative had recruited 254 industrial companies as Industrial Energy Innovators, representing about 74 percent of industrial energy use (see Figure 32). By March 2000, 195 participants had prepared action plans that describe their energy efficiency projects.

FIGURE 32
Industrial Energy Innovators and Action Plans, 1995–1996 to 2000–2001



Equipment

Energy Efficiency Regulations

Under the authority of the *Energy Efficiency Act*, NRCan sets *Energy Efficiency Regulations* for selected types of energy-using equipment to eliminate less efficient products from the market. The Regulations prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy performance levels. The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. NRCan funds and participates in nationally accredited standards-writing committees administered by CSA International to foster the development of these standards.

Achievements 2000–2001

- NRCan conducted analyses of energy savings and undertook consultations with the industry for the regulation of both dry- and liquid-type distribution transformers. An agreement for a voluntary standard has been drafted for liquid transformers. While an analysis for a mandatory standard is being done for dry transformers, consultations continue for a mandatory standard for dry-type transformers, which, along with the economic and environmental analysis, will result in minimum energy performance standards.

Industrial Sector: Equipment
Progress Indicators

FIGURE 33
Energy Savings from Motor Regulations, 2000 to 2020

The second amendment to the *Energy Efficiency Regulations* in 1997 raised the standard for industrial motors by about 5 percent. NRCan estimates that the aggregate annual energy savings from the amendment will be 5.9 petajoules in 2005 and will increase to 11 petajoules by 2020 in the industrial sector alone (see Figure 33). Together, energy savings in both the commercial and industrial sectors will lead to emissions savings of 1.33 megatonnes in 2005 and 2.14 megatonnes in 2020.

Chapter 6
Transportation Sector

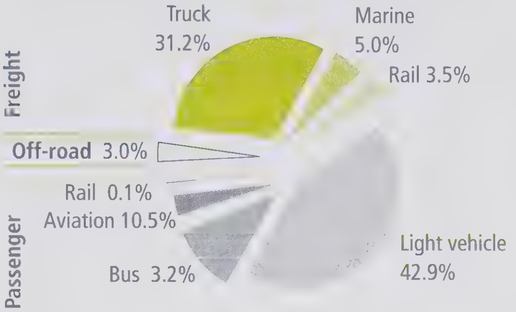
Energy Use and Greenhouse Gas Emissions

The transportation sector consists of three subsectors: passenger, freight and off-road. Passenger and freight transportation account for 56.7 percent and 39.7 percent, respectively, of transportation energy use, with off-road representing only 3.6 percent in 2000. The passenger subsector is composed of three modes: road, rail and air. The freight subsector comprises road, rail and marine. Road transport uses the most energy, accounting for 77.3 percent of total transportation energy use. Of this amount, 59.7 percent was passenger energy use and 40.3 percent was freight energy use (see Figure 34). All NRCan transportation energy-use programs focus on the energy used in road transportation.

Transportation energy use increased by more than 21.5 percent (404 petajoules) from 1990 to 2000 (see Figure 35). Passenger transportation energy use increased by almost 12.6 percent (145 petajoules), while freight transportation energy use increased by 34.1 percent (230 petajoules). Two main factors were responsible for this increase – activity and structure:

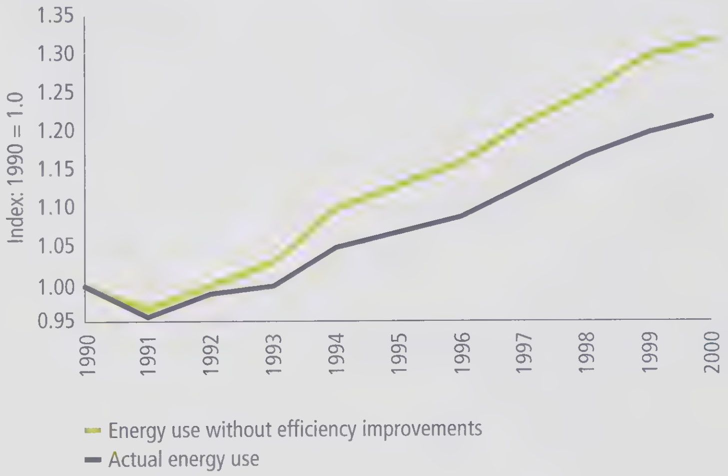
- *activity* – due to increases in population and economic activity, there was greater transportation activity (measured as passenger-kilometres for passenger transportation and tonne-kilometres for freight transportation). This increased transportation energy use by almost 23 percent (410 petajoules). The freight and passenger segments contributed to this increase by 60.4 percent and 39.6 percent, respectively; and
- *structure* – shifts between modes of transport were significant in the freight segment, resulting in an increase of more than 8.9 percent in transportation energy use (177 petajoules).

FIGURE 34
Transportation Energy Use by Mode, 2000



Total: 2282.1 petajoules

FIGURE 35
Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000



If only these two factors had been in effect, transportation energy use would have increased by almost 39.9 percent (588 petajoules). However, improvements in energy efficiency worked to decrease energy use by 11.3 percent (202 petajoules). As a result, energy use increased by only 21.5 percent. This change in energy use during 1990 to 2000, as well as the energy savings due to energy efficiency, is shown in Figure 35.

The transportation sector accounts for more than 28 percent (2282 petajoules) of secondary energy use and more than 34.5 percent (163 megatonnes) of GHG emissions. From 1990 to 2000, transportation energy use increased by more than 21.5 percent, and GHG emissions increased by 21.0 percent. The change in GHG intensity of transportation energy use was negligible.

NRCan delivers initiatives in the following areas to increase the efficiency of motor vehicles and encourage the use of alternative fuels:

- personal vehicles;
- commercial fleets:
- transportation research and development; and
- alternative transportation fuels.

Personal Vehicles

NRCan promotes the production and purchase of vehicles that are more energy efficient and the more energy-efficient use and maintenance of these vehicles through

- the Motor Vehicle Fuel Efficiency Initiative:
- EnerGuide for Vehicles: and
- AutoSmart.

Motor Vehicle Fuel Efficiency Initiative

The Motor Vehicle Fuel Efficiency Initiative is a voluntary initiative with vehicle manufacturers to improve motor vehicle fuel efficiency. The initiative encourages manufacturers to voluntarily meet standards for company average fuel consumption (CAFC) for new automobiles and light trucks sold in Canada. In addition, under a Memorandum of Understanding with domestic and international vehicle manufacturers, NRCan and the manufacturers pursue opportunities to improve both new vehicle and on-road vehicle fuel efficiency through changes to vehicle technology and the behaviour of vehicle owners and operators. This initiative is managed by NRCan and Transport Canada in co-operation with motor vehicle manufacturers.

Achievements 2000–2001

- NRCan initiated a technology cost assessment of heavy-duty trucks as part of its analysis of light, medium and heavy-duty vehicle market in support of vehicle energy programs.
- By fall 2000, NRCan had an agreement with the U.S. Department of Energy on motor vehicle fuel efficiency to study a voluntary fuel economy program.
- Compliance by vehicle manufacturers with voluntary CAFC goals for new 1998 model year light-duty vehicles covered 67 percent of companies, representing 98 percent of all car sales, and 60 percent of companies, representing 63 percent of total new truck sales.
- NRCan's Motor Vehicle Fuel Efficiency Initiative oversees improvement in the average fuel efficiency of new light-duty vehicle fleet, which for 1998 model year vehicles was 8.0 L/100 km for passenger cars and 11.4 L/100 km for light trucks.

EnerGuide for Vehicles

The EnerGuide for Vehicles program informs consumers about the fuel efficiency of new light-duty vehicles to help them choose the most fuel-efficient vehicle that meets their needs. Under a voluntary agreement, vehicle manufacturers affix an EnerGuide fuel consumption label to all new passenger cars, vans and light-duty trucks. The standard label shows the vehicle's city and highway fuel consumption ratings and estimated annual fuel cost. The annual *Fuel Consumption Guide*, which is available at vehicle dealerships, most motor vehicle agency offices and on the Internet, provides the same information for all light-duty motor vehicles. The annual EnerGuide for Vehicles Awards help make consumers aware of the model year's most fuel-efficient vehicles in each size class. The program works in close collaboration with Auto$mart, sharing the same Web site and toll-free publications line.

Achievements 2000–2001

- In February 2001 NRCan presented the EnerGuide for Vehicles Awards to eight winning manufacturers.
- NRCan measured the awareness of its program and its tools in several ways. For example, the number of Web site user sessions was 109 329 for the period April 1, 2000, to March 31, 2001.
- In March 2001 NRCan completed an analysis to establish a baseline for average class fuel efficiency and best-of-class L/100 km to monitor the future improvement in fuel efficiency of new light-duty vehicle fleets.
- Through dealerships for new cars, NRCan distributed 292 040 copies of the 2001 edition of the *Fuel Consumption Guide*. Additional copies were distributed at car shows and by direct mail. In total, nearly 500 000 copies of the guide were distributed to Canadians.

Auto$mart

Auto$mart encourages and assists motorists to buy, drive and maintain their vehicles in energy-efficient ways that save fuel and money, and emphasizes how such efforts also reduce vehicle emissions. Its main tool is the *Auto$mart Guide*, which offers useful information and tips on purchasing, operating and maintaining personal vehicles. The program also provides resource materials to driver educators for fuel-efficiency training to novice drivers and provides Web-based communications tools that support and encourage the development of new initiatives of local governments, industry and associations to promote fuel efficiency. Auto$mart also offers information on opportunities to use alternative fuels.

Achievements 2000–2001

- NRCan handled 11 166 toll-free calls, distributed 781 768 copies of publications (including the *Fuel Consumption Guide*) and had 172 854 visits to its Auto$mart Web site. In addition, 212 educators of new drivers ordered Auto$mart teaching resource kits, which reached 54 902 new drivers.

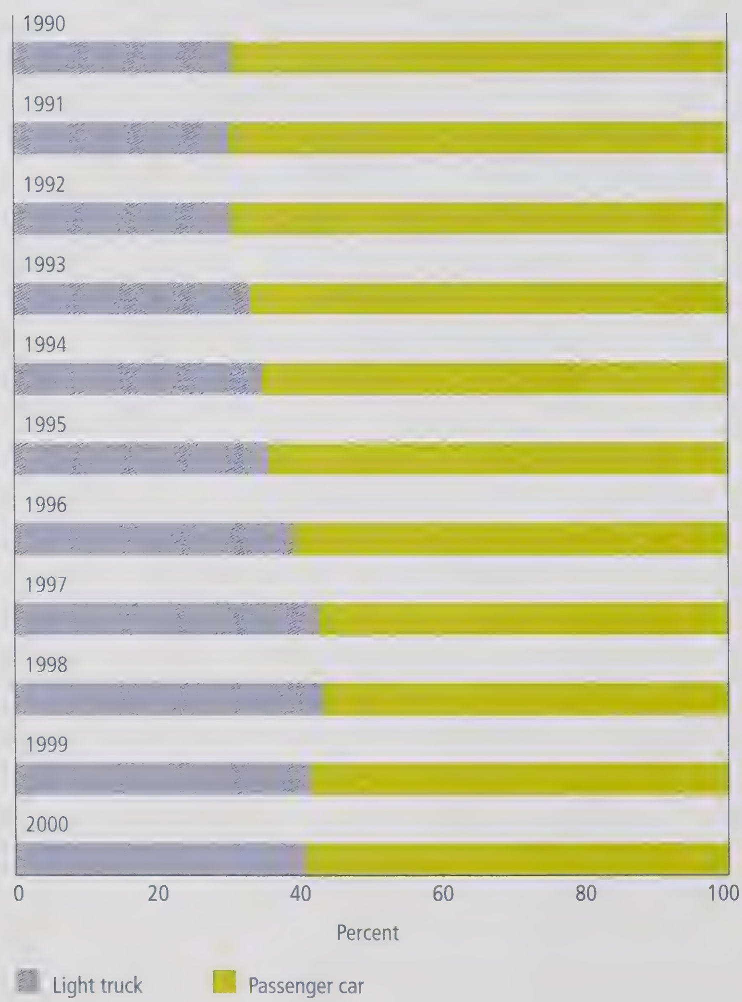
Progress Indicators

TABLE 4
Vehicle Vintage and Characteristics*

Year/vintage	1970s and earlier	1980s vintage	1990s vintage
Weight (tonnes)	2.0	1.5	1.6
Horsepower	135.0	100.0	140.0
Weighted average economy (L/100 km)	16.4	10.6	10.1

* Average new car from each model year.

FIGURE 36
Market Shares of New Light Trucks and Passenger Cars, 1990 to 2000



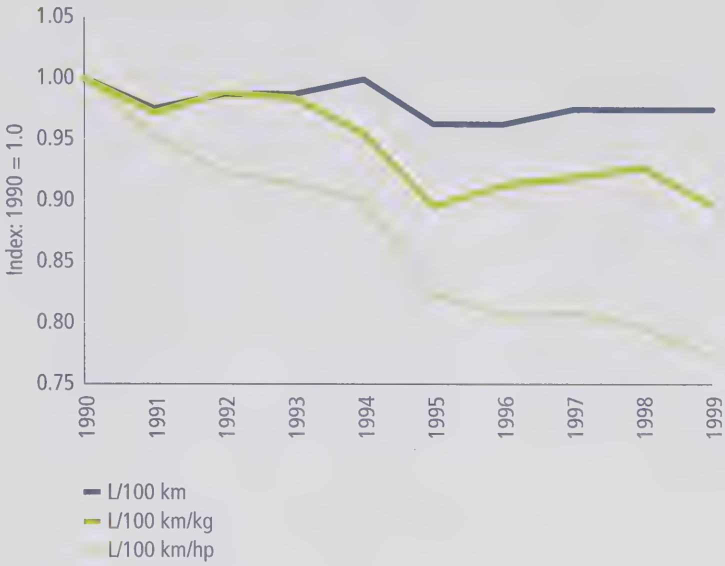
The conventional measure of transport fuel consumption is litres of fuel burned per 100 kilometres travelled (L/100 km). The most rapid fuel consumption improvements, measured in these units, occurred in the late 1970s and early 1980s, mainly because the newer vehicles weighed less and were less powerful than cars built in the 1970s. Vehicles built in the 1990s tend to be more powerful and, to a lesser degree, heavier, and this trend seems to have slowed new vehicle fuel efficiency improvements (see Table 4).

From 1990 to 2000, the energy intensity of the light-duty vehicle market (cars and light trucks) declined as more efficient vehicles came on the market. The average on-road fuel consumption of the total stock of light-duty vehicles in Canada improved by 2.1 percent from 1990 to 2000. These improvements occurred in the face of a trend toward heavier, more powerful vehicles in the latter part of the 1990s. For example, the share of light trucks in the new light-duty vehicle market increased from 30 percent in 1990 to 43 percent in 2000 (see Figure 36). As a result, the average fuel consumption of new 2000 light-duty vehicles (cars and light trucks combined) increased by 4.5 percent compared with the 1990 model year.

Progress Indicators (continued)

Fuel consumption measurements typically assume fairly stable service characteristics, i.e., features for safety, comfort or performance. Vehicle characteristics, however, have changed considerably. As a result, fuel efficiency improvements can be detected by using other indicators than the generally used measure of fuel economy (L/100 km). Two alternative ways to measure fuel efficiency are to standardize for weight and to standardize for power. These fuel consumption indicators have shown more rapid improvement than the L/100 km indicator. Whereas the fuel consumption (L/100 km) of new cars decreased by 2.4 percent from 1990 to 1999, the fuel consumption measured in terms of L/100 km/kg over the same period decreased by 10.3 percent; measured in terms of L/100 km/hp, it decreased by 22.7 percent. The negative impact of greater vehicle weight and power was more than offset by improved fuel efficiency (see Figure 37).

FIGURE 37
New Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 1999



Commercial Fleets

The Government of Canada has two initiatives to increase energy efficiency and the use of alternative transportation fuels:

- FleetWise, for the Government of Canada; and
- FleetSmart, for the private sector and other levels of government.

FleetWise

The FleetWise program helps the managers of federal fleets to improve their operational (including energy) efficiency and accelerate the use of alternative fuels to meet

- the federal objective of reducing 1995 levels of vehicle GHG emissions by 30 percent by 2000; and
- the vehicle acquisition requirements of the *Alternative Fuels Act* and Treasury Board of Canada Secretariat's Motor Vehicle Policy.

The initiative provides fleet managers with an assessment of fleets at little or no cost and technical advice on using alternative transportation fuels (ATFs) and acquiring alternative fuel vehicles. In addition, it campaigns to encourage vehicle operators to select alternative fuels. Four departments participate in planning and reporting on the initiative: Treasury Board of Canada Secretariat, NRCan, Environment Canada and Public Works and Government Services Canada. NRCan is responsible for implementing the initiative.

Achievements 2000–2001

- In its efforts to provide advice on fleet energy efficiency, vehicle procurement and alternative fuels, NRCan responded to 175 requests for information and advice by fall 2001 and published two issues of the FleetWise newsletter.
- NRCan conducted an annual update of cost, type and regional data for alternative fuel vehicles in its QTOOL database. This database is being used by the Department of National Defence as the basis for its automated database to select and confirm its acquisition of vehicles. The database remains the largest and most comprehensive source of information on alternative fuel vehicles, dealers for the service of these vehicles and incentives available to the public and to government.
- The federal vehicle fleet has met its alternative fuel vehicle (AFV) purchase requirements under the *Alternative Fuels Act*, acquiring 180 AFVs that represent 184 percent of the 98-vehicle requirement for 2000–2001. The combined use of the alternative fuels natural gas, propane and E85 in federal vehicle operations has increased to 2.8 percent on an energy-equivalent basis.
- The reduction in GHG emissions from federal fleet operations during the period 1995–1996 to 2000–2001 was 12 percent.

FleetSmart

FleetSmart aims to improve the fuel efficiency and use of ATFs in non-federal vehicle fleets. It provides information materials, workshops, technical demonstrations and training programs to help fleet operators assess and pursue opportunities to increase energy efficiency in their operations. NRCan delivers FleetSmart in partnership with fleet and industry associations and other levels of government.

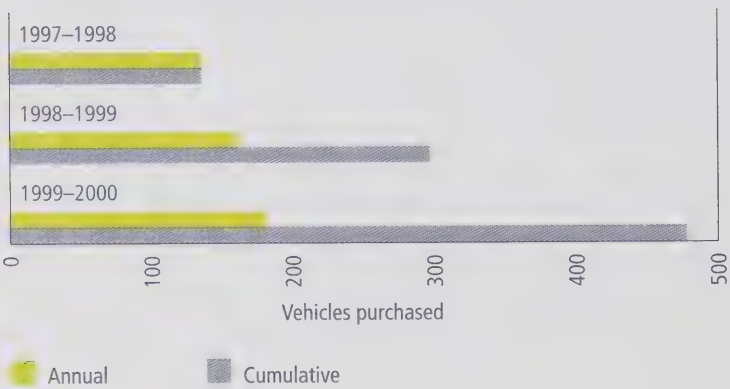
Achievements 2000–2001

- NRCan's SmartDriver Program now has 1526 new driver trainers using SmartDriver for Heavy Vehicles. In addition, 112 846 drivers – experienced and entry-level – have been exposed to the program during the last fiscal year.
- FleetSmart tool kits have now been distributed to 1643 registered clients, representing 132 323 vehicles. In addition, 3153 external users have visited the FleetSmart Web site during the last fiscal year.
- For the first time in its 17-year history, the Windsor Workshop targeted its transportation fuel and vehicle technologies information directly to fleet operators. NRCan, through its FleetSmart program, was invited to participate. FleetSmart introduced the new Fleet Management Audit Tool. This tool is intended to provide fleet owners and fleet managers with the necessary tools to construct an energy management plan. Built on four phases, the Audit Tool teaches how to conduct a fleet inventory and establish a baseline; determine opportunities, costs and benefits; create an action plan; and analyse performance.
- NRCan has entered into an agreement with the Canadian Urban Transit Association, the Canadian Bus Association and the Motor Carrier Passenger Council of Canada to develop a fuel efficiency driver training program based on the successful SmartDriver for Heavy Vehicles Program.

Progress Indicators

FIGURE 38
Federal Fleet Size and Fuel Consumption, 1995–1996 to 1999–2000

FIGURE 39
Purchases of ATF Vehicles for the Federal Fleet



Since the FleetWise initiative was launched in October 1995, the fleet of federal, on-road civilian vehicles has decreased by about 2400 vehicles – almost 10 percent. At the same time, the annual fuel consumption of the fleet declined by more than 10 million litres (gasoline equivalent) – almost 12 percent. The annual consumption per vehicle decreased by 70 litres, or almost 2 percent (see Figure 38).

During the last three fiscal years (1997–1998 to 1999–2000), the Government of Canada purchased 473 ATF vehicles (see Figure 39). During this period, the share of these vehicles in the federal fleet increased slowly to 3 percent as older ATF vehicles were replaced.

Transportation Research and Development

NRCan promotes energy efficiency and the use of ATFs and ATF vehicles through the Transportation Energy Technologies Program.

Transportation Energy Technologies Program

The Transportation Energy Technologies Program works in partnership with industry to develop and disseminate leading-edge transportation technologies that minimize environmental impacts, increase the potential for job and economic growth and extend the life span of Canada's energy resource base. Program areas include

- the development of alternative fuels and advanced propulsion systems (gaseous fuels, alcohols, hydrogen, fuel cells, electric vehicles and hybrids and related systems);
- advanced energy storage systems (lightweight cylinders, adsorption technologies and flywheels);
- emissions-control technologies (for diesel and alternative fuel engines, lean-burn catalysts and enhanced combustion chamber design);
- vehicle transportation system efficiency (advanced materials and processes, auxiliaries and regenerative breaking systems); and
- fuelling infrastructure (fuelling-station hardware, hydrogen systems and battery-charging systems).

The program works in co-operation with stakeholders in the domestic and international transportation industries, including original equipment manufacturers (OEMs), industry associations, fleet managers, transit authorities, utilities, provincial governments, research organizations, universities, other federal departments, the U.S. Department of Energy and the International Energy Agency.

Achievements 2000–2001

- NRCan supported two vehicle "challenge" events for students in order to raise awareness about more climate-friendly vehicles and vehicle fuels. At the 2000 Ethanol Vehicle Challenge in Ottawa, Ontario, NRCan served as a host, organizer and sponsor. Participating university teams converted Chevrolet Silverado trucks to run on E85 (a blend of 85 percent ethanol and 15 percent gasoline); the trucks were then run through a series of tests and trials. NRCan also sponsored the Future Truck 2001. This challenge strove to maintain the performance of the production model Chevrolet Suburban, while reducing fuel consumption, GHGs and exhaust emissions.
- Prime Minister Jean Chrétien, Minister Ralph Goodale and Ministers John Manley, David Anderson and David Collenette drove the fuel cell-powered Ford P2000 car. The P2000 car incorporates a fuel cell engine developed by Ballard Power Systems Inc. and its associated company, XCELLSIS, with funding from NRCan through PERD and from Industry Canada. The P2000 vehicle was developed under the Partnership for a New Generation of Vehicles, a joint initiative between the U.S. government and the "big three" automakers. Its aim is to make available by 2004 fuel cell cars that are extremely low-polluting and three times as fuel efficient as today's vehicles.
- NRCan provided financial support to Hydrogenics Corporation of Mississauga, Ontario, to develop an automated test station specifically designed for residential fuel cells. The first appliance of its type, it will lead to the design of better products and help to document the environmental benefits of residential fuel cells. The test station will also help to achieve compliance with international accords on emissions reductions. The project received funding from the Technology Early Action Measures component of the Climate Change Action Fund (CCAF-TEAM).
- NRCan and CCAF-TEAM provided funding to Dynetek Industries Ltd. for the design, building and testing of an ultra-high-pressure cylinder for storing compressed hydrogen that will extend a vehicle's driving range by more than 30 percent.

- NRCan co-sponsored the 16th Windsor Workshop along with Environment Canada and the U.S. Department of Energy. The workshop, held in Toronto, Ontario, was attended by more than 160 people. It focused on transportation fuels in the context of climate change and the environment. Topics included transportation technology and Canadian and U.S. perspectives on transportation, policies and programs. Manufacturers' views on off-road, light and heavy-duty vehicles, emissions issues and future emissions legislation were highlighted.

Alternative Transportation Fuels

NRCan promotes the development and use of ATFs and ATF vehicles through the Future Fuels Initiative and the Natural Gas for Vehicles Incentives Program.

Future Fuels Initiative

The Future Fuels Initiative encourages the development, production and use of alternative and future vehicle and fuel technologies. The fuels include propane, natural gas, alcohols, electricity and hydrogen. The initiative provides support to fleet operators in the public and private sectors through economic and market studies, emissions and safety assessments, market demonstrations, communications and awareness activities, and general and technical information about fuel options in Canada. The initiative periodically sponsors workshops with the industry and other governments to review market, technical and policy issues.

Achievements 2000–2001

- NRCan has co-chaired and supported the activities of the Council of Energy Ministers working group on ethanol. This working group was created in fall 2000, initiating federal-provincial discussions on the opportunities and issues regarding an expansion of the ethanol industry. This work has helped facilitate further federal interdepartmental discussions between Health Canada, Environment Canada, Agriculture and Agri-Food Canada, and NRCan on the growth of the industry, leading to future co-operative efforts for joint research, policy and program initiatives.
- Canada's domestic production of fuel ethanol was about 175 million litres in 2000; use reached about 240 million litres at more than 1100 stations across six provinces.

Natural Gas for Vehicles Program

The Natural Gas for Vehicles Program applies to regions of Canada served by Alberta natural gas. This program was renewed in February 1999 and is scheduled to run until January 31, 2002. The program was modified effective January 1, 2001, to provide contributions of $2,000 for each factory-built natural-gas light vehicle and $3,000 for each factory-built heavy vehicle, a $500 incentive for dealers to sell new factory-built natural gas vehicles, $500 for road vehicles converted to use natural gas, a contribution to help foster new refuelling outlets, marketing and awareness activities, and co-funded R&D. The incentives are sourced from the Market Development Incentive Payments fund, which was created in the early 1980s with receipts from Alberta's upstream natural gas producers for the purpose of expanding markets for Alberta natural gas.

Achievements 2000–2001

- By fall 2001, NRCan approved contributions for 95 new (OEM) vehicle purchases, 70 vehicle conversion contributions and one commercial station contribution ($50,000 in total) since March 31, 2001.
- By the fall of 2000, there were 143 natural gas fuelling facilities available to the public, and annual sales of new 2000 model year (OEM) natural gas vehicles reached 195, of which 65 were purchased by the Government of Canada.

Progress Indicators

The annual level of conversions of motor vehicles from gasoline to propane declined from 24 000 in 1991 to 1000 in the year 2000 (see Figure 40). This decline is attributable to several factors, including the restructuring of major propane-distribution companies through mergers, technical difficulty in converting newer vehicles to propane, the decline in the price difference between gasoline and propane, and significant volatility in propane prices.

The propane industry cites additional variables that have influenced the decline in propane conversions, including the following:

- Increased conversion equipment costs. In addition, propane-conversion equipment technology is lagging behind improvements in gasoline engine technology.
- Former propane auto fleets may be switching to diesel fuel to realize fuel cost savings.

A limited availability of factory-produced propane-powered vehicles acts as another market barrier to the use of propane in the transportation sector.

The annual rate of conversions of gasoline-powered vehicles to natural gas also declined, from about 5100 in 1991 to about 800 in 2000. This is attributable to a decline in the price differential between gasoline and natural gas and technical difficulties in converting vehicles manufactured after 1995. However, the volume of natural gas sold through public and private stations has been stable in recent years. Part of the reason for this is that the market is moving increasingly to high-usage fleets, with transit buses making up approximately one third of the national demand.

FIGURE 40
Conversion of Vehicles to Natural Gas and Propane, 1990 to 2000

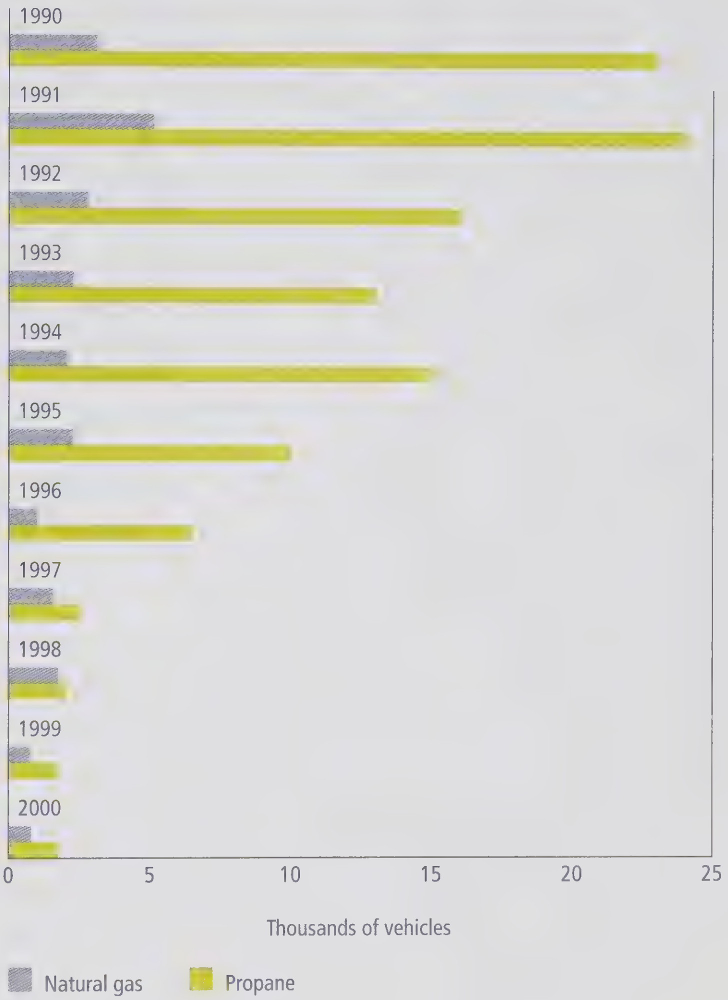


FIGURE 41
Number of Stations Selling Ethanol-Blended Fuels, 1990 to 2000

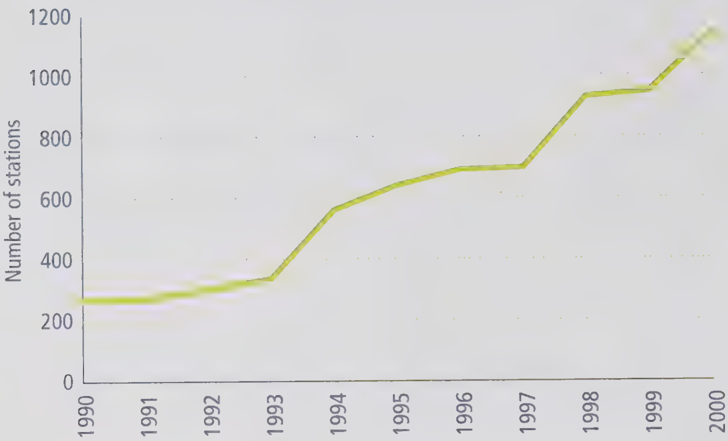
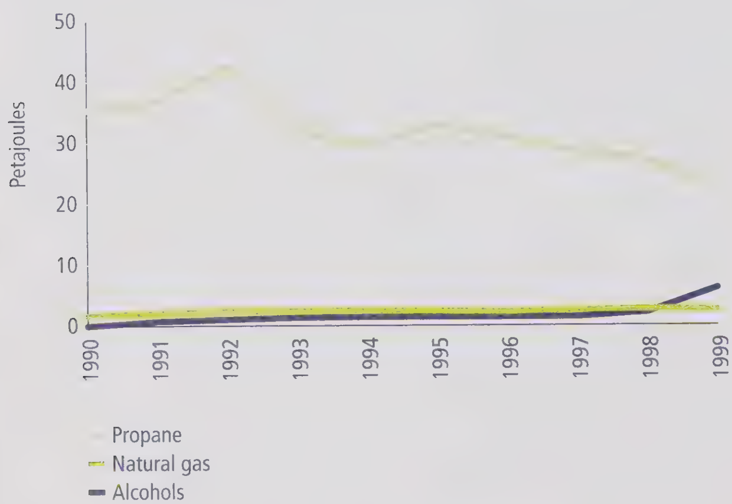


FIGURE 42
Use of Alternative Transportation Fuels, 1990 to 1999



Progress Indicators (continued)

The number of fuelling stations selling ethanol-blended gasoline increased from 266 in 1990 to 1140 by March 2000 (see Figure 41). The increase resulted from the introduction of ethanol blends into the Ontario and Quebec markets. Ethanol-blended gasoline is now sold in provinces from British Columbia to Quebec. Propane is the most widely available ATF. There were about 111 000 propane vehicles in the vehicle stock in 2000. Use of this fuel peaked in 1992 and decreased by about one third by 2000. Natural gas use has changed little from 1992 to 1999, while the use of alcohol fuels increased eightfold since 1991 (see Figure 42).

Chapter 7

Renewable and Community Energy

Introduction

Renewable energy sources are those that produce electricity or thermal energy without depleting resources. Renewable energy includes solar, wind, water, earth and bioenergy, including energy from waste.

NRCan delivers several initiatives to encourage the development and use of emerging renewable energy sources and technologies. However, these initiatives do not apply to the following renewable energy resources:

- large-scale hydro-electricity, a well-established renewable energy source; and
- ethanol fuel production from agricultural feedstocks, which is covered under Agriculture and Agri-Food Canada programs.

Each renewable energy source depends on one or more energy production technologies, with their own level of economic attractiveness. Some technologies are mature and well recognized (e.g., hydro-electricity), others are emerging in the marketplace, and many are in the laboratory stage but offer promise for the long term. Renewable energy sources compete in many markets, including those for electricity, mechanical power, thermal energy (process heat, space heating and cooling, and water heating and cooling), and transportation fuels (see Table 5).

Renewable Energy Use

In 1998, renewable energy sources accounted for about 17 percent of Canada's primary energy use, which is 1922 out of 10 826 petajoules (see Table 6). Most of the renewable energy used in Canada comes from either hydro-electricity or thermal energy from biomass such as wood-waste sources.

TABLE 5
Renewable Energy Markets and Technologies Used in Canada

Electricity	*Thermal Energy*
Hydro-electricity	Biomass (e.g., roundwood, pellets, wood chips)
Tidal power	Ground-source heat pumps (e.g., earth energy)
Biomass (e.g., wood waste)	Solar air-heating systems
Biogas (e.g., methane from landfill sites)	Solar hot-water systems
Wind turbines	
Photovoltaic systems	
Mechanical Power	*Transportation*
Wind water pumps	Ethanol from biomass

TABLE 6
Estimates of Primary Energy Production from Renewable Sources, 1998

	Petajoules
Hydro	1255
Tidal	0.1
Biomass	
industrial pulp and paper (IPP) electricity from wood waste and spent pulping liquor	100
IPP electricity from wood waste	37.5
electricity from landfill sites	7.2
electricity from municipal solid waste (MSW)	0.5
municipal waste incinerators	12.5
biogas from sewage plants	n/a
IPP heat from wood waste	393
residential space heating	95
commercial/institutional heating	n/a
thermal energy from landfill sites	2.4
thermal energy from MSW	12
ethanol from biomass	4.1
energy crops plantations	–
agriculture wastes	n/a
Earth energy systems	1.5
Wind electric	1.2
Wind mechanical	n/a
Solar thermal (water and air)	0.2
Solar photovoltaic	0.01
Total renewable energy	**1922.2**

– number too small to include
n/a not available

Hydro-Electricity

Hydraulic power is a renewable energy based on the water cycle – evaporation, precipitation and flow of water toward the ocean. Canada has abundant water resources, and its geography provides many opportunities to produce low-cost energy. Tapping the energy from moving water has played an important role in the economic and social development of Canada for the past three centuries.

Hydro-electricity constitutes about 11 percent of Canada's primary energy, and most of this is generated from large-scale facilities. It is the dominant source of electricity in Canada, accounting for nearly two thirds of total electricity generation. Small-scale hydro-electric projects, with a capacity of 20 Megawatts or less, constitute about 2 percent of Canada's electricity-generating capacity (more than 1500 Megawatts). Small-scale hydro has good potential for increased production.

Biomass

Bioenergy is a renewable source of energy derived from organic substances known as biomass. Biomass is supplied by agricultural wastes such as chaff, straw, grain screenings, husks and shells, food-processing residues and methane. Other biomass supplies include animal litter and manure, landfill gas methane, urban wastes to be incinerated and sewage for biogas. Bioenergy contributes approximately 6 percent of Canada's primary energy, mostly for industrial process heat, electricity generation and residential space heating. Corn and other agricultural products are also used to generate ethanol and biodiesels for the transportation market.

Bioenergy production represents Canada's second largest renewable energy sources. Most bioenergy is produced from organic refuse and used with the facilities in which the energy conversion takes place. The pulp and paper industry produces and uses most of Canada's bioenergy. Industrially produced heat and electricity, independent power producers' electricity, electricity from urban wastes, and residential wood heat are all considered commonplace in Canada's energy mix.

Home heating with wood usually takes the form of stand-alone wood stoves, water or forced-air wood furnaces, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters. About 3 million Canadian households use wood for home heating. Canadians usually prefer roundwood, but alternatives include wood chips and pellets.

Earth Energy

As a result of the sun heating the surface of the planet, the temperature of the earth that is one or two metres below the surface remains fairly constant – between 5°C and 10°C. This is warmer than outside air during the winter and cooler than outside air during the middle of summer. A ground-source heat pump takes advantage of this temperature difference by using the earth or the ground water as a source of heat in the winter and as a "sink" for heat removed from indoor air in the summer. For this reason, ground-source heat pumps are known as earth energy systems (EESs).

During winter, EES installations remove heat from the earth using a liquid, typically an antifreeze solution, that circulates within an underground loop. It then upgrades the heat with a conventional heat pump and transfers it to indoor space or the water heating system. During summer, the system reverses this process to operate as an air conditioner. EES installations supply less than 1 percent of the market for space and water heating and cooling in Canada.

Wind Energy

Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada has a very large wind resource potential because of its large size and its northern location. A 1992 NRCan study estimated the technical wind energy potential in Canada at about 28 000 Megawatts. If developed, this could supply 11 percent of total Canadian electricity consumption.

The first sizable wind farm developed in Canada is located at Cowley Ridge, near Pincher Creek, Alberta. Facilitated by Alberta's *Small Power Research and Development Act* of 1988, it was built in the early 1990s and had a capacity of

about 20 Megawatts. In October 2000, Cowley Ridge Windplant expanded to include five more turbines. This addition accounts for an additional 2 Megawatts of capacity. The electricity is sold to TransAlta Corporation under a long-term contract. Canadian Hydro Developers, Inc. and Shell Canada Limited have entered into a three-year agreement to purchase electricity from these turbines. Several other wind energy facilities across Canada, mostly single-turbine facilities, contributed a further 5 Megawatts of capacity during the year 2000.

Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairies. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses.

Solar Energy

Three main technologies use energy from the sun:

- using passive solar technologies, buildings are designed and located to maximize their reception of solar energy;
- active solar thermal systems convert solar radiation into thermal energy for heating air or water in residential, commercial and industrial applications; and
- solar electric (photovoltaic) systems use solar radiation to produce electricity.

During the 1990s, NRCan assisted a Canadian company in developing a perforated solar absorber to preheat ventilation air and reduce a building's fuel requirements for space heating. This technology is much more cost-effective than conventional solar air heating technologies and is gaining acceptance in Canada and abroad. Systems have been installed on industrial, institutional and commercial buildings throughout Canada.

Initially used to power spacecraft and satellites, photovoltaic systems convert sunlight directly into electricity by using solar cells made from semiconductor materials. The installed capacity of photovoltaic systems in Canada in 2000 was about 7.154 Megawatts, with an estimated annual production of 6.44 GWh of electricity. The bulk of this capacity is either "off grid" (not connected to an electrical transmission system) where the price of photovoltaics is competitive with conventional stand-alone power systems or extensions of a grid to a given location. Typical applications include telecommunications systems, water pumping and purification, remote monitoring and control, remote residences, coast-guard lighting and beacon systems, and numerous consumer applications such as hand-held calculators. The Canadian Coast Guard is the largest individual user of photovoltaic systems in Canada, with an estimated 7000 navigational buoys, beacons and lighthouses.

Canada has approximately 100 grid-connected photovoltaic systems, and they have a combined capacity of 315 kW.

Renewable Energy Programs

NRCan delivers several initiatives to increase the use of small-scale renewable energy in Canada:

- Renewable Energy Capacity Building Program;
- Renewable Energy Deployment Initiative (REDI);
- Renewable Energy Information and Awareness Program;
- Renewable Energy Market Assessment Program;
- Green Power Initiative;
- Renewable Energy Technologies Program;
- Photovoltaic and Hybrid Systems Program; and
- Energy From the Forest Program (ENFOR).

NRCan also provides technical advice to the Canada Customs and Revenue Agency on applications by companies to depreciate their assets under Class 43.1 of the *Income Tax Act*. This class provides an accelerated capital cost allowance to manufacturing and process industries for certain types of energy-efficient or renewable energy equipment. NRCan advises on whether the equipment in question meets or would meet the technical conditions spelled out in regulations.

Renewable Energy Capacity Building Program

The Renewable Energy Capacity Building Program (RECAP) promotes the dissemination of renewable energy systems in Canada and abroad by building the capacity of industry to implement more projects successfully. The program helps achieve this goal by

- creating knowledge via the development of enabling tools, such as software, databases, maps and manuals;
- transferring knowledge to clients via awareness generation, information dissemination and training activities through such mediums as the Internet, CD-ROMs, training materials and case studies, professional training workshops, colleges and universities; and
- providing project implementation support in high-priority markets such as Canadian remote communities, Canadian federal, provincial and municipal facilities and the Organisation for Economic Co-operation and Development (OECD) and developing countries.

Achievements 2000–2001

- RECAP, in collaboration with REDI and the OEE, helped promote the dissemination of renewable energy systems in the Northwest Territories, Nunavut and the Yukon by providing ongoing technical support and RETScreen® International training assistance to the Arctic Energy Alliance of Yellowknife and the Canada-Yukon Energy Solutions Centre of Whitehorse. As a result of these partnerships, numerous project actives were initiated. Examples include the installation of the following:
  - a Solarwall® for a recreation centre in Fort Smith, Northwest Territories;
  - a Solarwall® for an elementary school in Yellowknife, Northwest Territories;
  - a solar water heater for a demonstration home in Kahnawake, Quebec;
  - a Solarwall® for an apartment building in Iqaluit, Nunavut;
  - a solar water heater for a municipal pool in Haines Junction, the Yukon; and
  - a number of other projects that are under further study or design, including a Solarwall® project for a school in Rankin Inlet, Nunavut.
- RECAP provided follow-up technical support for a number of RETScreen® pre-feasibility studies prepared by RECAP for potential renewable energy projects in Canadian remote communities. Several of these projects are moving forward in the development process, including the following:
  - a wind turbine project for the community of Peawanuck, Ontario, where a joint venture is under consideration by the community, Indian and Northern Affairs Canada, the Federal Economic Development Initiative for Northern Ontario and Suncor Energy Inc.;
  - a wind turbine project for the community of Fort Severn, Ontario, with Hydro One Inc.;
  - two potential Solarwall® projects in Haines Junction, the Yukon;
  - a biomass heating project for a motel in Obedjiwan, Quebec;
  - a biomass heating project for the community of Pelly Crossing in the Yukon with the support of the CANMET Energy Technology Centre; and
  - a small-hydro project for the community of Lac Barrière, Quebec.
- Both the RETScreen® International Renewable Energy Project Analysis Software and the new Web-based satellite-derived RETScreen® "Surface Meteorology and Solar Energy Data Set" (e.g., global wind speeds, heating degree-days) were released by NRCan, along with the United Nations Environment Programme and NASA respectively, in October 2000. There are now more than 18 000 RETScreen® users in 182 countries. A new RETScreen® Web site was released in October 2000, and close to 200 000 people have received information on RETScreen®. RETScreen® also received a Northern Housing Award from the organizers of the international Circumpolar Housing Forum 2000 conference.

Renewable Energy Deployment Initiative

REDI aims to stimulate demand for renewable energy systems for space and water heating and cooling. REDI targets four systems: solar water-heating systems, solar air-heating systems, ground-source heat pumps (earth energy systems) and high-efficiency, low-emission biomass combustion systems. REDI promotes these systems in the business, federal and non-business markets, mainly through

- financial incentives – Businesses and Government of Canada departments are eligible for an incentive of 25 percent of the purchase and installation costs of a qualifying system, to a maximum contribution of $50,000 per installation;
- marketing – NRCan, in partnership with the renewable energy industry, develops marketing strategies and assessments in addition to promotional, advertising and information campaigns; and
- infrastructure development – NRCan helps the industry develop and deliver training programs, produce design tools, update and develop standards for renewable energy systems, and create a nationwide network of renewable energy technology specialists.

Achievements 2000–2001

- During 2000–2001 period, 24 projects were completed under the business incentive portion of the REDI program, representing $1.9 million in investments in renewable energy projects and more than $330,000 in REDI contributions. Of these projects, 12 were biomass systems, 6 were solar hot-water systems and 6 were solar air systems.
- In April 2000, a contribution agreement was signed with the Energy Action Council of Toronto for a solar domestic hot-water pilot project in the area of Toronto, Ontario. To date, nine systems have been installed, and another 12 installations are under way as of March 31, 2001. It is anticipated that an additional 6 systems will be installed by the end of the project, for a total of 27 systems. Under this project, 14 of the systems will be monitored to measure energy savings.
- Another pilot project under REDI with Peterborough Green-Up is being carried out in two phases in the area of Peterborough, Ontario. During Phase I, eight solar hot-water systems were installed from different manufacturers that were selected through a tendering process. The eight systems were monitored for performance for one year, and the best performing system(s) will be selected for installation in Phase II. As of March 31, 2001, Peterborough Green-Up had completed 15 site assessments of the 60 inquiries they received from interested homeowners for Phase II installation.
- NRCan continued to take steps to reduce market barriers and increase the visibility of ground-source heat pump (GSHP) systems and the growth of the GSHP industry in Canada, through partnerships with the U.S. Geothermal Heat Pump Consortium, Inc. and the Earth Energy Society of Canada. REDI teamed with CSA International to develop CSA 448, a new standard relating to the design and installation of GSHP systems, which also provided an opportunity to introduce underground thermal energy storage technology as an annex. In co-operation with other NRCan programs, REDI stimulated three federal and three institutional projects that incorporate GSHP systems by assisting organizations in areas such as project investment analyses, financing and contracting approaches and strategies for sustainable energy management.

Renewable Energy Information and Awareness Program

The goals of this program are to expand the use of renewable energy technologies and stimulate the growth of the renewable energy industry. Its activities focus on examining the information needs of market participants (i.e., potential users of renewable energy and the renewable energy industry) and preparing specialized information to show how renewable energy technologies can economically and reliably help meet Canada's energy needs.

Achievements 2000–2001

- NRCan introduced several new publications during the year, including
  - *Residential Solar Pool Heating Systems: A Buyer's Guide*;
  - *An Introduction to Residential Earth Energy*;
  - *Warm Up to Biomass and Improve Your Bottom Line*;
  - *Solar Water Heating – Good for Business and the Environment*;
  - four biomass energy use case studies; and
  - "REDI, Set, Go" – a tool kit for municipalities.
- During the year, NRCan distributed more than 200 000 publications on renewable energy technologies.
- NRCan also launched a new Web site dedicated to renewable energy technologies called the Canadian Renewable Energy Network (CanREN). Canadians can now access this site at www.canren.gc.ca. CanREN's objective is to increase the understanding of renewable energy and to accelerate the development and commercialization of renewable energy technologies.

Renewable Energy Market Assessment Program

The objectives of this program are to review renewable energy resources and use, and to determine the potential of commercially available technologies for meeting Canada's energy needs and environmental goals. Its activities include compiling data on demand and supply constraints, evaluating market prospects for existing and new technologies, and developing strategies to increase the capacity of the renewable energy industry to meet demand in identified markets.

Achievements 2000–2001

- During 2000 a study to assess the implications of Canada's Greenhouse Gas Emission Reduction Trading (GERT) program for the earth energy industry was conducted. The report outlined potential opportunities for the earth energy industry in emissions-reduction trading and made strategic recommendations for participation in GERT or a related program.
- In December 2000 NRCan hosted 11 focus groups across the country to determine rural and urban wood burners' attitudes toward burning wood as a primary or secondary heating source. The sessions considered issues with respect to underlying attitudes toward wood heating; probed the knowledge of basic wood-burning life-cycle facts; obtained insight on motivating factors and barriers to change; and determined preferred communications channels by wood burners.
- During 2000–2001, NRCan issued a Request for Letters of Interest to undertake pilot marketing initiatives in three regions of Canada to promote solar heating for outdoor residential pools. This initiative followed an NRCan study on the potential for the solar heating of outdoor residential pools to 2020. As a result of the Letters of Interest, three regions were selected for pilot projects: the suburbs of Montréal, Quebec; Niagara Falls, Ontario; and Vancouver, British Columbia.
- To promote the use of solar thermal systems, NRCan undertook several feasibility studies, including a study to look at the use of unglazed solar hot-water systems in Canadian car washes. The study examined the cost of glazed and unglazed systems compared with that of conventional heating systems at a car wash in southern Ontario. In addition, a market development study was completed on the potential of the car wash industry in Canada for solar hot-water applications. Feasibility studies were also conducted on the use of solar thermal technologies on NRCan buildings in Ontario, Quebec and British Columbia.

Green Power Initiative

Under the Green Power Initiative, NRCan purchases electricity generated from renewable energy sources and encourages other federal departments to do the same. NRCan has pledged to purchase 15 to 20 percent of its electricity from new green power sources by 2010, wherever it makes economic sense. NRCan made its first green power purchase in Alberta in 1998.

Achievements 2000–2001

- Due to the successful initial purchase of green power in Alberta, the Government of Canada announced in its 2000 budget that it would expand this pilot initiative to procure $15 million of renewable energy over the next 10 years in Saskatchewan and Prince Edward Island. Along with Nova Scotia, these three provinces (Alberta, Saskatchewan and Prince Edward Island) have the most carbon-intensive electricity in Canada. An agreement with SaskPower, Saskatchewan's electric utility, was announced in October 2000.

Renewable Energy Technologies Program

The Renewable Energy Technologies Program supports efforts by Canadian industry to develop renewable energy technologies, including bioenergy (combustion, biochemical conversion of biomass to ethanol, thermochemical conversion of biomass to bio-oil and biogas, and biomass preparation and handling), small-hydro projects (less than 20 Megawatts), active solar applications and wind energy.

NRCan champions and supports technology development and field trials in partnership with the renewable energy industry. Activities are directed toward improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users, and helping industry commercialize its products in domestic and foreign markets.

Achievements 2000–2001

Bioenergy

- NRCan supported CFS Alternative Fuels Inc. in the successful pilot scale demonstration (at the Hartland landfill in Victoria, British Columbia) of an innovative cryogenic technology that produced two high-quality products from raw landfill gas: vehicle-grade liquefied natural gas (LNG) fuel suitable for use in heavy duty vehicles; and pure industrial-grade CO_2. The cryogenic landfill-gas processing technology was developed at the University of Victoria. The Technology Early Action Measures component of the Climate Change Action Fund (CCAF-TEAM) also contributed financially to this project.
- Iogen Corporation is in the final stages of commissioning its $30-million demonstration plant to produce ethanol (4 million litres per year) from cellulosic biomass. This is the final step in the development of this technology before commencing construction of full-scale commercial plants in 2003. Iogen's partners in the demonstration plant are Petro-Canada, which has invested $15.8 million, and the Government of Canada, which has contributed $10 million to Iogen to be repaid out of royalties from successful commercial plants. The demonstration plant will incorporate the use of state-of-the-art, high-efficiency cellulose enzymes currently being developed under a cost-shared research and development (R&D) program between NRCan and Iogen Corporation.

Wind

- State-of-the-art wind turbine blade manufacturer Polymarin-Bolwell Composites (PBC) Inc. of Huron Park, Ontario, has successfully developed and tested a new manufacturing process called Vacuum Assisted Resin Transfer Moulding (VARTM). The process allows more competitive, lower weight, higher strength glass fibre or carbon/glass fibre wind turbine blades, aircraft flight simulator bodies and safer and cleaner and working conditions.

- PBC has used the VARTM process to manufacture large and small wind turbine blades (e.g., four 37-metre blades for 1.5-megawatt wind turbines and 5-metre blades for a 25-kW wind turbine) and 85 aircraft flight simulator bodies. This process was developed with co-funding by NRCan (sourced from the PERD and CCAF-TEAM programs).

Solar

- NRCan signed an agreement with Environment Canada's Environmental Technology Centre to support experimental activities to evaluate an innovative solar-based advanced oxidation technology that uses UV from natural sunlight and a photocatalyst to treat organic contaminants in water. Bench scale tests were successfully completed in preparation for the first field tests in the summer at the Trail Road Waste Facility in Ottawa, Ontario. The process will be evaluated against other technologies on the effectiveness in reducing the concentrations of toluene, xylenes and hydrogen sulfide in the excess leachate from the landfill site.

Small Hydro

- A 1.0-megawatt low-head site at Leszno Gorne, Poland, has been developed by Merol Power Corporation of Barry's Bay, Ontario, and has been in operation since February 2001. The project, which is the result of the October 1996 first commercial mission to Poland, used Canadian small-hydro technology and constitutes the first project to be registered by Poland under the Polish-Canadian Joint Implementation Program.
- NRCan has supported the expansion of Université Laval's turbine laboratory test-bench facility since 1994. The latest phase was completed in the fall of 2000, making it the only independent hydro-turbine testing facility in Canada based on international standard test-codes. A major hydro-turbine manufacturer has signed a contract to undertake testing at the laboratory, and contracts for testing hydro-power equipment are currently under negotiation with other major hydro producers.

Photovoltaic and Hybrid Systems Program

The Photovoltaic and Hybrid Systems Program supports the development and application of solar photovoltaic (PV) technologies in Canada. Expertise is available for technical and economic studies for PV systems, the development and testing of PV systems components, the design and optimization of PV-Genset hybrid systems and their application in cold climates, the development of product standards and electrical installation codes, and the development of advanced modelling and simulation software tools. The program has been expanded to support the development of building-integrated PV for grid-connected applications in Canada.

Achievements 2000–2001

- NRCan co-authored and edited a technical report entitled *Connecting MicroPower to the Grid*. This report provides a review of micropower interconnection issues and related codes, standards and guidelines in Canada for four emerging technologies – photovoltaic, microturbines, fuel cells and on-site wind turbines. This report is important since it recommends joint action by various technology stakeholders for the development and harmonization of product standards and their interconnection to the electrical grid in Canada. It addresses issues related to the reliability of the electrical grid, the safety of workers and the time and cost for approving installations. The report can be obtained from the Web site at www.micropower-connect.org.
- NRCan co-authored and submitted changes to the CSA C22.2 107.1 standard to incorporate the safety requirements for PV equipment. The amendments to the standards cover inverters used to convert DC power to AC power, DC charge controllers used to manage the energy flow in stand-alone systems, and utility-interconnected inverters used to convert the DC power that is produced from a PV system and that can be fed directly to the utility grid on-site.

- NRCan co-authored and submitted changes to the *Canadian Electrical Code* (Section 50). These changes were required to establish rules for the safe installation of PV power sources for off-grid and grid-connected applications in Canada.
- NRCan prepared a comprehensive report that examined the benefits of on-site generation using PV technology in buildings in Canada. The report, entitled *Photovoltaics for Buildings: Opportunities for Canada*, was prepared after consultations with other federal departments, industry, municipalities, consultants and associations. The report concludes that there are strong economic reasons for recommending PV for buildings in Canada.

Energy From the Forest Program

The Energy From the Forest (ENFOR) Program, managed by the Canadian Forest Service (CFS), undertakes R&D on forest biomass for energy through the private sector, universities and CFS research centres. The goals are to improve the understanding of the role of biomass production for energy and to improve biomass productivity in conventional forest stands and plantations. Two primary sources of forest biomass for energy are under study: forest residues, including harvest residues; and energy plantations, involving short-rotation intensive culture in fast-growing trees, such as willow and poplar. ENFOR also supports research on information systems to determine the quantity and quality of biomass in Canadian forests.

The forest also plays a role in the global carbon cycle, which is linked to climate change. ENFOR seeks to better understand the role of Canada's forests in reducing atmospheric CO_2 emissions. It also investigates the broad environmental effects of harvesting and using forest biomass for energy, focusing on sustaining forest productivity and improving the sequestration and storage of atmospheric carbon in forest ecosystems.

Achievements 2000–2001

- Under the International Energy Agency Bioenergy Agreement, the CFS continued to collaborate in international projects on the production of forest biomass, the use of conventional forestry for biomass production, GHG balances of bioenergy systems, and the socio-economic aspects of bioenergy production. These projects form an integrated approach to the production and use of bioenergy while contributing to the reduction of GHG emissions and strengthening the economic base of rural communities. The major products of this collaboration have been a series of workshops, seminars and publications. This sharing of knowledge and technology has facilitated the establishment of many demonstration plantations and infrastructure (boilers, conversion plants) for the generation of electricity from biomass feedstock. Generating plants have been established in the Netherlands, Sweden and the U.K.
- NRCan developed a framework document for the implementation of bioenergy based on the products developed by previous programs and consideration of the opportunities for and barriers to increased use of biomass for energy. The framework outlines the impact of national and international commitments on energy policy to guide decisions and activities for increased bioenergy use in the Canadian energy context.
- NRCan completed a study on biomass residue recovery from hardwood-harvesting operations. The study determined the quantities of biomass produced by harvesting operations, the cost of recovering these residues, the level of environmental concern by the public over areas where forestry operations take place, and the amount of interest in using this biomass for bioenergy or other purposes. The study examined the potential for job creation and the economic spinoff associated with biomass recovery from conventional harvesting operations.

- NRCan completed the evaluation and harvest of a willow biomass plantation established on disused farmland. The evaluation provided estimates of biomass yields for five promising clones of willow and explored the sustainability of this type of biomass production in southern Quebec. Studies on poplar examined methods to increase productivity, enabling a reduction in the area needed for the exploitation of natural forest lands.

Renewable and Community Energy: Renewable Energy Programs

Progress Indicators

FIGURE 43
Canadian Wind Power Capacity, 1990 to 2000

Wind power is a viable option for supplying renewable energy, particularly in remote, off-grid communities. In addition, there has been an increase in the number of large wind turbines connected to the grid, particularly in Alberta and Quebec. As of March 2000, installed capacity had increased to approximately 125 Megawatts, reflecting additions to capacity at the Le Nordais project in the Gaspé region of Quebec (see Figure 43).

During the third year of REDI, NRCan approved 24 applications from Canadian businesses for renewable energy systems, representing NRCan contributions of more than $330,000 (see Table 7).

TABLE 7
REDI for Business Projects Completed in 2000–2001

Business name	Building type	Province	Type of system	NRCan contribution	Project cost
Graner Farms	Farm	Saskatchewan	Biomass	$2,802	$11,206
Élevage et Grains Gelé Inc	Farm	Quebec	Solar air	$12,529	$50,116
Lafontaine Lodge Ltd.	Seniors' Residence	Ontario	Solar hot water	$26,693	$106,772
Chestnut Canoe Company	Manufacturer	Ontario	Biomass	$1,715	$6,862
The Chanterelle Country Inn Ltd.	Inn	Nova Scotia	Solar hot water	$9,196	$36,782
ICP Global Technologies Inc	Warehouse	Quebec	Solar air	$10,489	$42,000
Aurum Experience Ltd.	Inn	Alberta	Solar hot water	$5,568	$22,273
Location d'outils Knowlton	Retail	Quebec	Biomass	$3,789	$15,156
Everest Equipment Inc (#2)	Manufacturer	Quebec	Solar air	$3,209	$165,595
Fort Steele Resort & RV Park	RV Park	British Columbia	Solar hot water	$2,000	$8,022
Greenwood Forest Products (1983) Ltd.	Manufacturer	British Columbia	Biomass	$50,000	$398,657
Bois Laurentide Inc.	Manufacturer	Quebec	Biomass	$10,294	$41,177
Shermag Inc.	Manufacturer	Quebec	Biomass	$50,000	$250,000
Shermag Inc.	Manufacturer	New Brunswick	Biomass	$50,000	$340,000
NMF Canada Inc.	Manufacturer	Quebec	Solar air	$37,468	$150,000
MTR Developments Ltd.	Manufacturer	British Columbia	Solar air	$6,331	$25,326
Summerside Inn	Inn	Prince Edward Island	Biomass	$2,467	$9,867
Fabridor Inc.	Manufacturer	Quebec	Solar air	$7,238	$28,952
Le Campagnard de Sutton	Farm	Quebec	Biomass	$9,355	$37,420
Brudenell Hog Farm	Farm	Prince Edward Island	Biomass	$6,549	$26,196
Les jardins d'hiver… Maurice	Greenhouse	Quebec	Biomass	$11,113	$44,451
Roma's Beauty Salon	Hair Salon	Ontario	Solar hot water	$3,247	$12,988
Willowdale Farms Ltd.	Farm	Prince Edward Island	Biomass	$3,388	$13,550
Gestion Christian St. Pierre	Garage	Quebec	Solar hot water	$1,638	$6,550
Total				**$1,849,918**	**$327,078**

Community Energy Systems

The Community Energy Systems Program works in partnership with Canadian communities and businesses to help address their energy needs through a holistic approach to energy efficiency and renewable energy. The program identifies and develops opportunities for the use of local resources such as biomass and landfill gas in the application of district heating and cooling, combined heat and power (cogeneration), waste-heat recovery and thermal storage. The program provides planning and implementing services for projects in urban centres and remote communities, moving the communities toward a position of increased sustainability. Continuing work is also undertaken on the analysis of the improved performance of district cooling systems. It also promotes and fosters the adoption of integrated energy systems. The program's laboratory, which houses an ice-slurry-based district cooling system, develops and tests district energy technologies.

Achievements 2000–2001

- NRCan used its technical expertise to assess, advise, design, troubleshoot or manage district heating and cooling systems in more than seven communities across Canada, including Halifax, Nova Scotia; Medicine Hat, Alberta; Arviat, Nunavut; Ottawa and Perth, Ontario; Hull, Quebec; Revelstoke and Masset, British Columbia – and one in the United States (Montpelier, Vermont).
- NRCan, in partnership with Enbridge Consumers Gas, Kinectrics and the Department of Public Works and Government Services Canada, installed a 75-kW microturbine at a Health Canada laboratory in Toronto, Ontario. The unit used a prototype heat recovery system fabricated by Unifin International of London, Ontario, which has since sold more than 100 units to Europe and the U.S.
- NRCan proved the ability of microturbines to destroy odour-causing compounds by partnering with Centra Gas Manitoba Inc., Manitoba Hydro, the City of Winnipeg and the Province of Manitoba in installing a microturbine at a Winnipeg waste-water treatment plant where hydrogen sulphide emissions were of concern. The foul air stream was mixed with the microturbine combustion air intake, eliminating the odour while producing both power and heat.

Chapter 8

Intergovernmental Co-operation

Introduction

This chapter describes NRCan's inter-governmental co-operation with respect to energy efficiency and alternative energy (EAE) during the reporting period at three levels: municipal, provincial/territorial and international. Other examples of inter-governmental co-operation are set out in Chapter 1 and Chapters 3 to 7 in the "Achievements" sections of specific EAE program initiatives.

Federal–Provincial and Federal–Territorial Co-operation

Provincial and territorial governments delivered a substantial number of EAE programs during the reporting period in order to reduce energy costs, increase competitiveness, improve air quality and generate economic and trade opportunities. Co-ordination between the federal and provincial/territorial levels is essential to avoid duplication and ensure efficient program delivery. During the reporting period, the governments co-operated at the general level and at the level of specific program initiatives.

General Co-operation

Co-operation took place through two main mechanisms: Letters of Co-operation (LOCs) and the National Action Committee on Energy and the Environment (NACEE).

Letters of Co-operation

- NRCan had an LOC on EAE with Quebec's Agence de l'efficacité énergétique during the reporting period. The LOC ensures an efficient consultation and exchange of information between the two governments, and it helps to co-ordinate EAE activities in the province and create opportunities for joint projects. The management committee established under the LOC met twice a year during the reporting period to review policy and program developments, progress on joint program initiatives and areas for further co-operation.

  The LOC played a considerable role in facilitating the conduct of the following three activities in particular:

  – the management of the licensing agreement for the EnerGuide for Houses program (which is delivered by the Agence de l'efficacité énergétique in Quebec);

  – the conclusion of a contribution agreement between the OEE and the Agence de l'efficacité énergétique under the Commercial Building Incentive Program (CBIP) regarding projects submitted to NRCan by public organizations in Quebec. The co-operation framework that was agreed upon in February 2000 is now being applied to other NRCan Energy Sector programs aimed at the public sector in Quebec; and

  – the management of the agreement between NRCan (CANMET Energy Diversification and Research Laboratory at Varennes, Quebec) and the Agence de l'efficacité énergétique relating to the Programme d'intervention en réfrigération dans les arénas. Among other activities, an important study was completed to evaluate the potential energy savings and GHG emissions reduction in Quebec's arenas.

- Another LOC on energy efficiency and renewable energy was signed in March 2001 between the Government of Canada and the Government of the Yukon with similar objectives, i.e., facilitating information exchange and creating opportunities for joint projects in the Yukon. The first project under the LOC was the creation of a joint Energy Solutions Centre in Whitehorse, the Yukon, which started operations in December 2000. The Centre provides access to relevant technical services to the Yukon population, undertakes outreach

and public education activities, and delivers assigned energy efficiency and renewable energy programs in the Yukon.

National Advisory Council on Energy Efficiency

- NRCan created the National Advisory Council on Energy Efficiency (NACEE) in April 1998 to advise and guide the OEE on the most effective way to achieve its mission. During 2000–2001, NACEE members included representatives from four provinces – Manitoba, New Brunswick, Quebec and Saskatchewan – who had the opportunity to comment on the OEE's business plan and programs.

Co-operation at the Program Level

R-2000 Program

- In 2000–2001, the R–2000 Program was delivered in seven provinces (Alberta, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario and Saskatchewan) and in the Yukon. Provincial home builders' associations, except in Manitoba and the Yukon, participated in the delivery of the program. There were three types of co-operation during the period:
  - Representatives from most provinces and the Yukon participated as members of regional R-2000 Advisory Committees.
  - In New Brunswick, Newfoundland, Nova Scotia and Saskatchewan, the provincial governments and NRCan supported the program through financial or in-kind contributions.
  - In Manitoba and the Yukon, the provincial and territorial governments delivered the program under a licensing agreement with NRCan.

EnerGuide for Houses

- Several provinces and the Yukon participated in the EnerGuide for Houses Advisory Committee.
- The Yukon Housing Corporation and Quebec's Agence de l'efficacité énergétique are the delivery agents of the program in their jurisdictions, under licensing agreements with NRCan.

Commercial Building Incentive Program

- Provinces distributed information on CBIP. Provincial health and education departments were active participants in the program as eligible parties.

Energy Innovators

- A number of provincial and territorial departments and health and education organizations registered as Energy Innovators during the reporting period. Several health and education organizations received financial assistance under the Energy Innovators Plus program.

Equipment Energy Efficiency Regulations

- NRCan and five provinces (British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec) regulate the energy efficiency performance of prescribed equipment. They share information and consult through CSA International's Advisory Committee on Energy Efficiency.

Green Power Initiative

- The February 2000 federal budget announced that the Government of Canada would expand the pilot Green Power Initiative to procure $15 million of renewable energy over the next 10 years in Saskatchewan and Prince Edward Island. NRCan entered into discussions with SaskPower and Maritime Electric on the purchase of green power for federal facilities in their provinces.

Residential Wood Combustion

- NRCan is a member of the Intergovernmental Working Group on Residential Wood Combustion co-chaired by Environment Canada and the Newfoundland Department of Environment and Labour. The Federal Smog Management Plan calls for the following four initial joint actions pertaining to residential wood combustion:

- assess the effectiveness of pilot wood stove change-out programs and consider options for a national program;
- complete an update of CSA International standards on wood stoves, fireplace inserts and solid-fuel-burning central systems and further the development of similar standards for fireplaces;
- support public education on cleaner wood burning with advanced technologies and sustainable wood use: and
- develop a federal regulation on residential wood combustion, focusing on cleaner-burning appliances.

- NRCan chairs the cross-jurisdictional steering committee that is developing a Canada-wide education campaign on safe. clean and efficient residential wood heating. NRCan works with health industry partners, the Canadian Lung Association, the Canadian Environmental Network and Fire Prevention Canada in preparation of the initial launch of the campaign in fall 2002.

Driver Education

- NRCan has successfully partnered with the Alberta Department of Transportation to incorporate the topic of fuel efficiency in its basic operator's handbook and in the final test that novice drivers need to pass in order to obtain their driver's licences.

Federal–Municipal Co-operation

- The Town of Banff, Alberta, mandated the R-2000 Standard for new residential construction by the Banff Housing Corporation.
- A number of municipalities received financial incentive contributions in 2000–2001 under CBIP.
- A number of municipalities registered as Energy Innovators during the reporting period, and some received financial assistance under the Energy Innovators program.
- A working group of seven municipalities (Saanich, the City of North Vancouver and the District of North Vancouver. British Columbia; Edmonton, Alberta: North Battleford. Saskatchewan: Montréal, Quebec; and Gander, Newfoundland) was formed in 1999–2000 to oversee the development of a tool kit for municipal fleet managers. This tool kit, part of the new Municipal Vehicle Energy Use Reduction Program being developed under the FleetSmart program, will provide information on energy management planning, vehicle specifications, alternative fuels, preventive maintenance, computerized productivity tools and driver training. One activity of the working group in 2000–2001 was to design and include a comprehensive energy audit component in the tool kit with the intent of pilot-testing it in 2001–2002.
- NRCan pursued its discussions with the Federation of Canadian Municipalities (FCM) after the department identified the municipal sector as a potential market for the purchase and use of renewable energy technologies. In 2000–2001, the FCM developed a strategy to raise the level of awareness of the program (in particular, of solar energy technologies) in the Canadian municipal sector and to identify an initial group of prospects for the development of pilot projects and case studies.

International Co-operation

NRCan also co-operates with several international organizations and foreign governments. Canada benefits from this co-operation in the following two ways:

- Canada learns about improved ways of designing and delivering EAE programs: and
- this co-operation helps to reduce trade barriers to energy-using products through the harmonization of energy efficiency tests and performance standards.

International Energy Agency

Canada is a member of the International Energy Agency (IEA), an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD).

NRCan serves on a number of committees that review policies and undertake studies on energy efficiency and related issues. These committees include the Standing Group on Long-Term Co-operation (SLT) and the Energy Efficiency Working Party (EWP), which reports to the SLT. The SLT develops policy analyses to promote conservation and the efficient use of energy, while the EWP/SLT carries out more detailed studies on specific energy efficiency issues.

Canada is an active member of the IEA's Centre for the Analysis and Dissemination of Demonstrated Energy Technology (CADDET). CADDET is an international information network to help managers, engineers, architects and researchers learn about energy-saving technologies that have worked in other countries. Canada co-operated with 11 OECD countries during the reporting period.

Canada also collaborates on several agreements and programs of the IEA that are oriented toward research and development (R&D) and technology and that are undertaken with research centres in member countries.

Asia-Pacific Economic Co-operation

Since the first meeting of energy ministers of the Asia-Pacific Economic Cooperation (APEC) in August 1996, NRCan has played a leading role in efforts to ensure that efficiency test standards for energy-using appliances do not become barriers to trade within the APEC region. Acting on the ministers' directions, NRCan has chaired the APEC Energy Working Group's Steering Group on Energy Standards since 1996. In 2000, the work plan of this working group was incorporated into that of the Expert Group on Energy Efficiency and Conservation.

During the reporting period, the group started investigating the prospects for developing ways to determine energy performance by one test procedure (from the results generated by testing to another test procedure). This investigation focused on domestic refrigerators and air conditioners. Additional studies were initiated to survey manufacturers and regulators regarding the acceptance of these results. Reports are expected to be finalized in the third quarter of 2001–2002.

Also under the APEC Energy Working Group, NRCan participates in the Expert Group on New and Renewable Energy Technologies. Activities of the working group during the reporting period included exchanging information on new and renewable energy technology programs, technologies and R&D strategies; fostering co-operation in priority areas; conducting technology transfer seminars; analysing projects for APEC funding; and monitoring progress in the accepted projects. On the domestic side, NRCan provided information to interested Canadian parties in the private sector and government on opportunities for collaboration, potential opportunities for technology transfer and information exchange, and on upcoming APEC seminars.

Hemispheric Energy Initiative

The Hemispheric Energy Initiative (HEI) is the energy component of the action plan arising from the Summit of the Americas and supporting the Hemispheric Energy Ministers Meetings. The aim of the HEI is to advance sustainable development and use of energy in the hemisphere. The HEI has eight "outcomes," one of which is the promotion of energy efficiency in the hemisphere. NRCan leads on one component of this outcome – the promotion of energy efficiency in equipment and buildings.

Research and Development

NRCan facilitates R&D and commercial business ventures by Canadian firms abroad by undertaking a wide variety of activities, including participating in various IEA tasks and supporting technical and trade-oriented workshops and conferences.

United States

Motor Vehicle Fuel Efficiency and Fuels

In March 1996, NRCan and the U.S. Department of Energy signed a Memorandum of Understanding (MOU) concerning road transportation, energy efficiency and alternative fuels. The MOU provides a formal mechanism for negotiating and harmonizing North American policy on fuel efficiency, as Canada and the U.S. consider options in responding to their respective climate change commitments. Three important studies are currently being conducted under the MOU: the first study aims at developing an analytical framework for estimating the technological response to any new initiative to improve the fuel economy of future new vehicles and applying that framework to assess the impact on three selected manufacturers and their products; the second study analyses the emissions-reduction potential of gas and diesel engines in North America; and the third study analyses the potential costs and benefits of the 42-volt hybrid system for vehicles.

Mexico

NRCan signed an MOU on EAE co-operation with the Mexican Energy Secretariat in June 1996. The objective of the MOU is to contribute to the EAE objectives of both countries by

- improving the design and delivery of EAE programs implemented or sponsored by NRCan and the Mexican national commission for energy savings (Comisión Nacional para el Ahorro de Energía, or CONAE); and
- enhancing trade, investment and exchanges (technical and other) related to energy-efficient products, energy management services and alternative energy goods and services.

China

NRCan and China's Ministry of Water Resources signed an MOU in May 1997, under which they have jointly undertaken extensive work. Some projects undertaken in 2000–2001 include demonstration of small-hydro control systems, a joint venture between Powerbase Automation Systems Inc. (Carleton Place, Ontario) and the Hangzhou Regional Centre (Asia Pacific) for small-hydro power, and training Chinese technicians to install and maintain control systems.

Appendix 1

NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 2000–2001

(millions of dollars)

General Programs **$ 8.77**
General Management
Public Information
Community Energy Systems Program
National Energy Use Database
Corporate Services

Energy Efficiency – Equipment **2.42**
Energy Efficiency Regulations
EnerGuide for Appliances
EnerGuide HVAC Energy Efficiency Rating System

Energy Efficiency – Buildings **26.59**
R-2000 Program
Model National Energy Code for Houses
Model National Energy Code for Buildings
Buildings Energy Technology Advancement Plan
EnerGuide for Houses program
Commercial Building Incentive program
Federal Buildings Initiative
Federal Industrial Boiler Program
Buildings Program

Energy Efficiency – Industry **25.03**
Industrial Energy Efficiency
Industry Energy Research and Development Program
Emerging Technologies Program
Energy Innovators Initiative
Industrial Process Integration Program
Industrial Process Engineering Program
Advanced Combustion Technologies Program
Energy Technologies for High Temperature Processes Group
Processing and Environmental Catalysis Program
Minerals and Metals Technologies Initiative

Energy Efficiency – Transportation **3.87**
Motor Vehicle Fuel Efficiency Initiative
EnerGuide for Vehicles
Auto$mart
FleetWise
FleetSmart

Alternative Energy – Alternative Transportation Fuels **6.23**
Transportation Energy Technologies Program
Urban Energy Planning
Future Fuels Initiative
Natural Gas for Vehicles Program
Vehicle Technology

Alternative Energy – Renewable Energy Sources **17.05**
Renewable Energy Deployment Initiative
Renewable Energy Information and Awareness Program
Renewable Energy Market Assessment Program
Green Power Initiative
Renewable Energy Technologies Program
Photovoltaic and Hybrid Systems Program
Energy From the Forest Program
Electricity and Renewable Energy

Total* **$ 89.97**

*Figures do not add to total, due to rounding.

Appendix 2
Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for the purpose of energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix C of NRCan's *Energy Efficiency Trends in Canada 1990 to 1999*.

FIGURE 2: Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.98	1.00	1.02	1.06	1.07	1.11	1.12	1.09	1.13	1.17
Energy use without efficiency improvement	1.00	0.99	1.02	1.05	1.09	1.12	1.15	1.17	1.16	1.21	1.26

FIGURE 3: Canadian Households by Type of Dwelling, 2000 (percent)

Single detached	55.53
Apartments	31.68
Single attached	10.60
Mobile homes	2.19

FIGURE 4: Residential Energy Use by Purpose, 2000 (percent)

Space heating	62.73
Water heating	20.38
Appliances	11.18
Lighting	4.88
Space cooling	0.82

FIGURE 5: Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.04	1.12	1.08	0.98	1.02	1.07
Energy use without efficiency improvement	1.00	1.04	1.10	1.14	1.15	1.17	1.22	1.19	1.10	1.15	1.22

FIGURE 6: Annual Heating Costs for Houses Constructed to Different Standards, 1999 (dollars per year)

Typical existing house (1970)	1790
Typical new house (1999)	1134
Model National Energy Code house (1999)	897
R-2000 house	701

FIGURE 7: R-2000 Share of National Housing Completions, 1990 to 2000 (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
R-2000 Share	0.279	0.333	0.673	0.959	0.504	0.534	0.331	0.341	0.265	0.154	0.182

FIGURE 8: National Trends in Air Leakage in Houses by Construction Period (air changes per hour [at 50 pascals pressure])

1981–1985	5.38
1986–1990	3.67
1991–1995	3.05
R-2000 house (1981–1999)	1.10

FIGURE 9: Homes Evaluated and Labelled Under the EnerGuide for Houses Program

	Annual	Cumulative
1998–1999	4 686	4 686
1999–2000	9 145	13 831

FIGURE 10: Energy Use and Energy Savings – EnerGuide for Houses Program (gigajoules per year per house)

Period of construction	Energy use	Potential energy savings	Actual energy savings
Pre-1945	254	75	47
1945–1959	187	46	25
1960–1969	195	46	26
1970–1979	199	49	27
1980–1989	188	33	16
1990–1999	150	34	10
Average	**198**	**48**	**26**

FIGURE 13: Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 1999 (petajoules)

	Regulated	Unregulated
Space conditioning	556.0	223.0
Water heating	296.0	0.5
Appliances and lighting	117.0	133.0
Total	**970.0**	**357.0**

FIGURE 14: Average Energy Consumption of New Appliances, 1990 and 2000
(kilowatt hours per year)

	1990	2000
Clothes washers	1218	838
Clothes dryers	1103	910
Refrigerators	956	640
Dishwashers	1026	637
Ranges	772	760
Freezers	714	391

FIGURE 15: Natural Gas Furnace Sales by Efficiency Level, 1990 and 1999 (percent)

	1990	1999
Low-efficiency	63	0
Mid-efficiency	16	60
High-efficiency	22	40

Source: *Canadian Gas Facts*, Canadian Gas Association.

FIGURE 16: Unit Energy Consumption for Top-Mount Auto-Defrost Refrigerators Marketed in Canada, 1991 and 2001 Models

Source: Natural Resources Canada EnerGuide Database.

FIGURE 17: Commercial and Institutional Energy Use by Building Type, 2000 (petajoules)

Building type	Energy use	Percent
Retail	257.37	24.43
Office	259.23	24.65
School	146.46	13.93
Health	123.72	11.77
Hotel and restaurant	91.70	8.72
Recreation	64.12	6.10
Warehouse	52.12	4.96
Other institutional	44.65	4.25
Religious	12.12	1.15
Total	**1051.50**	

FIGURE 18: Commercial and Institutional Energy Use by Purpose, 2000 (petajoules)

	Energy use	Percent
Space heating	536.00	50.97
Lighting	152.91	14.54
Auxiliary motor	126.65	12.04
Water heating	107.23	10.20
Auxiliary equipment	80.86	7.69
Space cooling	47.85	4.55
Total	**1051.50** (excluding street lighting, 7.35 PJ)	

FIGURE 19: Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.14	1.15	1.09	1.13	1.23
Energy use without efficiency improvement	1.00	1.05	1.06	1.10	1.10	1.12	1.14	1.14	1.11	1.17	1.25

FIGURE 20: Energy Use in Commercial Buildings, 1999 (megajoules per m² per year)

All buildings (average)	1809
New buildings (average)	1300
Model National Energy Code	1105
CBIP target	829
C-2000 projects	553

FIGURE 21: Recruitment of Energy Innovators (Commercial and Institutional), 1992–1993 to 2000–2001 (organizations)

	Annual recruitment	Cumulative recruitment
2000–2001	148	728
1999–2000	80	580
1998–1999	100	500
1997–1998	40	400
1996–1997	50	360
1995–1996	110	310
1994–1995	100	200
1993–1994	70	100
1992–1993	30	30

FIGURE 22: Percentage of Commercial and Institutional Sectors Recruited

2000–2001	27
1999–2000	25
1998–1999	22

FIGURE 23: Energy-Saving Projects Under the Energy Innovators Initiative, 1992–1993 to 2000–2001 (number of projects)

	Annual projects	Cumulative projects
2000–2001	N/A	N/A
1999–2000	50	260
1998–1999	50	210
1997–1998	40	160
1996–1997	10	120
1995–1996	35	110
1994–1995	25	75
1993–1994	40	50
1992–1993	10	10

N/A = Not available

FIGURE 24: Federal Buildings Initiative Investment and Energy Savings
(millions of dollars)

	Investment as of March 2000	Estimated annual energy savings
Environment Canada	8.7	1.1
Natural Resources Canada	9.2	1.0
Industry Canada	13.1	2.3
Other departments	18.3	3.1
Public Works and Government Services Canada	41.0	6.3
National Defence	89.7	10.2

FIGURE 25: Energy Savings from the Federal Industrial Boiler Program, 1991–1992 to 1999–2000
(energy savings [terajoules per year])

	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000
Annual additions	20	50	40	70	90	80	77	77	93
Annual	20	70	110	180	270	350	427	504	597

FIGURE 26: Influence of Regulations on Energy Use of Two Fluorescent Lamp Types, 1996

	Before regulation–watt rating	After regulation–watt rating	Before regulation–kWh/yr	After regulation–kWh/yr
4-foot, medium bi-pin	40	34	140	119
8-foot, high-output	75	66	263	210

FIGURE 27: Energy Savings from Motor Regulations, 2000 to 2020 (petajoules per year)

	2000	2005	2010	2020
Industrial energy savings	2.2	5.9	9.5	11.0
Commercial energy savings	2.1	4.6	6.8	6.7

FIGURE 28: Industrial Energy Use by Subsector, 2000 (percent)

Industries not listed below	15.35
Pulp industry	13.39
Upstream mining	11.99
Petroleum refining	9.26
Newsprint industry	8.47
Iron and steel	8.04
Other paper industries	5.65
Other manufacturing n.e.c.	4.86
Primary production of aluminum	4.61
Industrial organic chemical industries	3.11
Industrial inorganic chemical industries	2.55
Paperboard industry	2.24
Other non-ferrous smelting and refining	2.45
Cement industry	2.08
Chemical fertilizers and fertilizer materials industries	1.82
Construction	1.56
Other food industries	1.32
Sawmill and planing mill products industry	1.25
Total	**100**

FIGURE 29: Cost of Energy to Industry as Percentage of Total Production Cost, 1998 (percentage)

Lime	39.14
Cement industry	35.20
Magnesium	25.93
Aluminum	17.83
Chemicals	9.94
Iron and steel	9.68
Pulp and paper	7.27
Semi-fabricated metals	5.76
Petroleum refining	2.19
Other manufacturing	0.74
Transportation equipment	0.70

FIGURE 30: Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.98	0.99	1.00	1.06	1.08	1.11	1.11	1.09	1.12	1.16
Energy use without efficiency improvement	1.00	0.98	1.00	1.02	1.08	1.11	1.12	1.15	1.15	1.20	1.25

FIGURE 31: Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 2000 (percent)

Electric and electronic	75.90
Glass	50.90
Gold mines	47.14
Rubber	41.40
Beverage	41.21
Motor vehicle parts and accessories	39.11
Other manufacturing n.e.c.	38.84
Potash mines	38.52
Furniture and fixtures	29.46
Salt mines	24.99
Other food	23.57
Organic chemicals	23.32
Peat	22.85
Primary textile	21.06
Brewery	20.27
Petroleum refining	20.26
Tobacco	17.24
Plastic	16.74
Iron mines	15.81
Meat and poultry	15.27
Aluminum	14.29
Lime	12.55
Paperboard	11.86
Other non-ferrous smelting and refining	11.33
Construction	9.97
Cement	9.51
Iron and steel	8.65
Motor vehicle	6.67

(Figure continued on page 97)

FIGURE 31: Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 2000 (percent) (Continued)

Gypsum	6.42
Building board	3.69
Plastic and synthetic resin	2.49
Other metal mines	-1.13
Pulp	-5.91
Other paper	-19.01

FIGURE 32: Industrial Energy Innovators and Action Plans, 1995–1996 to 2000–2001

	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001
Innovators	212	238	245	249	254	295
Action plans	18	193	198	215	222	230

FIGURE 33: Energy Savings from Motor Regulations, 2000 to 2020 (petajoules per year)

	2000	2005	2010	2020
Commercial energy savings	2.1	4.6	6.8	6.7
Industrial energy savings	2.2	5.9	9.5	11.0

FIGURE 34: Transportation Energy Use by Mode, 2000 (petajoules per year)

Passenger light vehicle	979.08
Freight truck	710.98
Aviation	239.46
Freight marine	113.99
Freight rail	80.55
Bus	73.19
Off-road	82.30
Passenger rail	2.53
Total	**2181.95**

FIGURE 35: Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22
Energy use without efficiency improvements	1.00	0.97	1.00	1.03	1.10	1.13	1.16	1.21	1.25	1.30	1.32

FIGURE 36: Market Shares of New Light Trucks and Passenger Cars, 1990 to 2000 (model year) (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Light truck	30.47	30.17	30.34	33.08	34.81	35.69	39.19	42.63	43.18	41.51	40.77
Passenger car	69.53	69.83	69.66	66.92	65.19	64.31	60.81	57.37	56.82	58.49	59.23

FIGURE 37: New Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 1999 (index: 1990 = 1.00)

	L/100 km	L/100 km/kg	L/100 km/HP
1990	1.000	1.000	1.000
1991	0.976	0.972	0.955
1992	0.988	0.989	0.924
1993	0.988	0.985	0.915
1994	1.000	0.956	0.901
1995	0.963	0.897	0.824
1996	0.963	0.914	0.807
1997	0.976	0.920	0.809
1998	0.976	0.928	0.798
1999	0.976	0.897	0.773

FIGURE 38: Federal Fleet Size and Fuel Consumption, 1995–1996 to 1999–2000 (litres of gasoline equivalent [thousands])

	1995–1996	1997–1998	1999–2000
Total fuel consumption	88 725	75 684	78 281
Vehicles	24 854	22 796	22 462

FIGURE 39: Purchases of ATF Vehicles for the Federal Fleet (vehicles purchased)

	Annual	Cumulative
1997–1998	135	135
1998–1999	159	294
1999–2000	179	473

FIGURE 40: Conversion of Vehicles to Natural Gas and Propane, 1990 to 2000 (thousands of vehicles)

	Natural gas	Propane
1990	3.12	23.00
1991	5.15	24.00
1992	2.78	16.00
1993	2.29	13.00
1994	2.08	15.00
1995	2.30	10.00
1996	1.01	6.50
1997	1.57	2.50
1998	1.75	2.00
1999	0.80	1.75
2000	0.80	1.00

FIGURE 41: Number of Stations Selling Ethanol-Blended Fuels, 1990 to 2000 (number of stations)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Number of stations	266	270	300	336	560	640	691	697	929	947	1140

FIGURE 42: Use of Alternative Transportation Fuels, 1990 to 1999 (petajoules)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Propane	35.36	36.71	42.49	31.56	29.70	32.81	30.89	28.27	27.16	22.63
Natural gas	1.66	2.09	2.33	2.40	2.49	2.35	2.22	2.55	2.68	2.52
Alcohols	0.00	0.73	1.04	1.32	1.39	1.39	1.39	1.39	2.10	6.07

FIGURE 43: Canadian Wind Power Capacity, 1990 to 2000 (megawatts)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Megawatts	4.5	4.5	4.5	0.5	21.0	21.6	21.8	25.3	50.0	75.0	125.0

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

The Office of Energy Efficiency of Natural Resources Canada
strengthens and expands Canada's commitment to energy efficiency
in order to help address the challenges of climate change.

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Canada

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act*

2001–2002

CANADA'S **NATURAL RESOURCES**
NOW AND FOR THE **FUTURE**
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The digital mosaic of Canada, produced by Natural Resources Canada (Canada Centre for Remote Sensing), is a composite of individual satellite images. The differences in the density of vegetation are illustrated through shading.

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Her Excellency the Right Honourable Adrienne Clarkson,
C.C., C.M.M., C.D.
Governor General of Canada and Commander-in-Chief

Your Excellency,

I have the honour to present the *Report to Parliament Under the* Energy Efficiency Act for the fiscal year ending March 31, 2002, in accordance with Section 36 of the Act.

Respectfully submitted,

Herb Dhaliwal

Herb Dhaliwal
Minister of Natural Resources Canada

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Minister's Foreword

This ninth report under the *Energy Efficiency Act* describes what the Government of Canada, through Natural Resources Canada (NRCan), has done in 2001–2002 to help improve our country's energy efficiency and use of renewable energy.

Herb Dhaliwal
Minister of Natural Resources Canada

The Government has been working to improve energy efficiency for a number of years. Specifically, NRCan has been helping industry, governments and individual Canadians reduce energy use and save money through voluntary initiatives, programs and regulations. NRCan also supports innovative research and development, leading to new technologies that have made Canada a world leader in energy efficiency and renewable energy.

The focus of the Government of Canada's programs has changed over time from energy conservation to addressing climate change. As we implement the Kyoto Protocol in Canada, we as a country will need to reduce our greenhouse gas emissions. Improving our use of energy at home, at work and on the road is the most effective way to address this global challenge.

We all need to take action — companies of all sizes, governments at all levels and individual Canadians. In our *Climate Change Plan for Canada*, we propose that every Canadian set the goal of reducing personal greenhouse gas emissions by an average of one tonne per year by 2008–2012. Making the right choices in our daily lives will bring us closer to this goal.

By promoting the responsible use of our energy resources, NRCan builds on the Government of Canada's commitment to ensuring the quality of life in our communities, a healthy environment and continued economic prosperity — for the Canada we want, for ourselves and for future generations.

Herb Dhaliwal

Herb Dhaliwal
Minister of Natural Resources Canada

Executive Summary

With its ratification of the Kyoto Protocol in December 2002, Canada has strengthened its commitment to doing its part to address the global issue of climate change. Canada's highly industrialized and resource-based economy makes reducing greenhouse gas (GHG) emissions, which contribute to climate change, a particular challenge.

Canadians spend almost $104 billion per year on energy to heat and cool our homes and offices and to operate our appliances, cars and industrial processes. An abundance of energy from a variety of sources helps us overcome the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. It has also favoured the development of industries that have a particularly high energy demand.

There are two types of energy use: primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (e.g., coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use is energy used by final consumers for residential, agricultural, commercial, industrial and transportation purposes.

In 2000 (the latest year for which data are available), secondary energy use accounted for 70.3 percent of primary energy use and 65.6 percent of GHG emissions.

The industrial sector is the largest energy user, accounting for 39.2 percent of total secondary energy use in 2000. The transportation sector is the second-largest energy user at 28.0 percent, followed by the residential sector at 17.0 percent, the commercial and institutional sector at 13.0 percent and the agriculture sector at 2.8 percent.

For the past decade, Natural Resources Canada (NRCan) has promoted energy efficiency and the use of alternative energy as a means to reduce GHG emissions. It has done this through initiatives under the department's Efficiency and Alternative Energy (EAE) program. The EAE program has provided a foundation for long-term processes that respond to evolving environmental and economic development priorities. It uses a variety of policy instruments, including leadership, information, voluntary actions, financial incentives, research and development and regulation.

There are four key factors that contribute to changes in energy use:

- Activity: Changes in the level of activity in a sector
- Structure: A shift toward more or less energy-intensive components of activity
- Weather: Fluctuations in the weather
- Energy efficiency: The level of energy consumption of a product or piece of equipment

As indicated in this report, increases in energy use are primarily due to increases in activity in the various sectors. These increases, however, would have been far greater without improved energy efficiency.

Between 1990 and 2000, the residential sector showed the greatest improvement in energy efficiency (15.1 percent). Transportation was second (11.3 percent), followed by the industrial sector (8.7 percent) and the commercial and institutional sector (2.7 percent).

Most of NRCan's EAE initiatives focus on improving energy efficiency by

- increasing the energy efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to purchase buildings, equipment, systems and vehicles that are more energy efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way possible;
- influencing the energy-use practices of individuals and organizations; and
- developing technologies to give consumers, industry and communities new opportunities to improve energy efficiency.

Improvements in energy efficiency contribute significantly to energy savings and environmental objectives. Similarly, changes in the fuel mix to less GHG-intensive fuels (e.g., from coal to natural gas) can in the short term help reduce GHG emissions. In the long term, reducing GHG emissions to 1990 levels or below will require greater use of alternative energy sources.

Solar, wind, wood and waste electric power consumption has steadily increased over the past 10 years. In 2000, Canadians consumed 9 terawatt hours (billions of gigawatt hours) of power from these sources.

Changing energy consumption patterns to obtain environmental and economic benefits is the main goal of NRCan's EAE initiatives. Measuring the effectiveness and progress of the initiatives is important to their continued success and viability.

NRCan monitors and tracks three aspects of program delivery:

- program outputs;
- program outcomes; and
- market outcomes.

Program outputs are the items that a program produces regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. These outputs are designed to lead to *program outcomes* – namely, achieving the goal of the particular program, such as changing the behaviour of groups targeted by that program. These outcomes can directly affect the amount and type of energy consumed in the market, therefore they contribute, in part, to observable *market outcomes*.

NRCan emphasizes partnership and cooperation with stakeholders such as other levels of government, the private sector and non-governmental organizations in the delivery of its programs. There are a number of cooperation agreements in place, primarily at the program level.

These initiatives engage Canadian society and all major sectors of the economy in new and more efficient approaches to secondary energy use – i.e., the consumption of energy in the residential, commercial and institutional, industrial and transportation sectors – and in the development and deployment of renewable energy sources.

Following is a brief overview of the work being done in each sector that highlights selected programs and indicators of their effectiveness and progress. All programs – their progress and accomplishments plus specific achievements for 2001–2002 – are fully described in the corresponding sector chapter. Program indicators are listed in Table 1 at the end of this section. A list of NRCan's EAE initiatives and expenditures in 2001–2002 is provided in Appendix 1.

Housing

The residential sector accounts for 17.0 percent of secondary energy use and 15.8 percent of GHG emissions. Between 1990 and 2000, residential energy use increased by 6.8 percent, and GHG emissions increased by 7.3 percent. This growth in energy use was largely driven by increased activity. However, improvements in energy efficiency, both through better construction of new homes and reduced energy use in the home, mitigated that increase. Without improvements in energy efficiency, supported by NRCan programs, the increase in energy use would have been 15.1 percent higher.

NRCan's residential building programs target three main subsectors – new houses, existing houses and residential equipment – and focus on single-detached and attached houses because they are the predominant residence type.

New Houses

Canada's ever-improving building codes have resulted in increasingly energy-efficient new homes. A review of air leakage rates shows that a home built before 1946 had a leakage rate of 10.73 air changes per hour (at 50 Pa). Today's more energy-efficient home has a leakage rate of 3.26.

NRCan's well-established R-2000 Initiative continues to encourage Canadians to build even more energy-efficient houses. The R-2000 Standard exceeds energy efficiency and environmental responsibility requirements in current Canadian building codes. With an air leakage rate of only 1.27, R-2000-built homes outperform conventionally built homes.

Since 1998, NRCan's Super E™ program has helped export energy-efficient and environmentally friendly housing technology to foreign builders. As a result, the R-2000 concept has been adapted to international markets. To date, 54 houses have been built in Japan, and in the United Kingdom one house is complete and 31 are under construction.

Existing Houses

NRCan programs for existing houses encourage Canadians to increase the energy efficiency of their homes. Through the EnerGuide for Houses program, NRCan signed contracts with 15 delivery agents in 2001–2002 to offer personalized expert advice to homeowners on how to improve energy efficiency. This service is now available to 80 percent of Canadians.

On average, houses that were built before 1946 and evaluated under the program had potential energy savings of 75 gigajoules – that is, homeowners could reduce their energy use by almost 30 percent. For homeowners who implemented some of the suggested changes, the actual average energy savings were closer to 17.6 percent.

Residential Equipment

NRCan develops regulations and sets standards for residential equipment performance. As of 2001–2002, products that consume 80 percent of the energy used in the residential sector are regulated under the *Energy Efficiency Act*.

Through labelling and promotion initiatives, NRCan also encourages the manufacture and purchase of more energy-efficient equipment.

Between 1990 and 2000, all common household appliances showed significant increases in energy efficiency. A comparison of the energy efficiency of 1991 and 2001 models of top-mounted, auto-defrost refrigerators shows a dramatic increase in energy efficiency. In 1991, a 25-cubic-foot model used approximately 1200 kWh per year. A 2001 model used approximately 650 kWh.

Between 1990 and 2000, there was a cumulative total energy savings of 531.3 GWh and a reduction of 287.8 kt CO_2e in GHG emissions attributable to this program.

Buildings

Retail and office space account for nearly half of the building sector's energy demands. Schools, health care facilities and hotels and restaurants account for another 35 percent.

Between 1990 and 2000, commercial and institutional energy use increased by 22.1 percent. In 2000, it accounted for 13.0 percent of secondary energy use and 12.6 percent of GHG emissions. However, without improvements in energy efficiency supported by NRCan programs, energy use would have increased by 25 percent.

NRCan's programs address all building types in this sector and target new buildings, existing buildings and equipment.

New Buildings

NRCan provides financial incentives to encourage builders and developers to incorporate energy-efficient features into new construction. In 2001–2002, 63 new contributions totalling more than $4.2 million were issued to builders.

The reduction of GHG emissions realized as a result of incorporating energy-efficient features were significant for all building types participating in the program. The biggest savings among participants came in new office construction, where GHG emissions were reduced by on average 203.17 tonnes per year.

Existing Buildings

NRCan gives commercial businesses and public institutions access to tools and financial assistance to invest in energy efficiency in their existing buildings. More than 700 organizations have made a formal commitment to energy efficiency and reduced GHG emissions.

Between 1998 and 2002, federal financial incentives have totalled $12.8 million, and client investment has totalled $259.7 million. Annual energy savings through these incentives total $32 million.

Equipment

Through its equipment programs, NRCan sets energy efficiency standards and regulations. It also supports the development, testing, deployment and promotion of new technologies.

Products that consume 50 percent of the energy used in the commercial and industrial sector must now meet energy efficiency standards. In 2000, the estimated savings of electricity used for lighting arising from the regulations is 39 petajoules. The resulting net reduction in GHG emissions is estimated at 5.5 megatonnes.

NRCan also develops and distributes building simulation software tools to support advancements in building technology. Architects and engineers use the tools to optimize energy performance. To date, these tools have been used to simulate the energy performance of more than 44 874 houses for NRCan's R-2000 Initiative and EnerGuide for Houses program and 799 buildings for the Commercial Building Incentive Program.

NRCan partners with associations, government and business to develop highly specialized solutions to reduce the energy consumption and GHG emissions of Canadian buildings in a cost-effective manner. The Canadian Centre for Housing Technology is just one joint effort. The centre is co-managed by NRCan, National Research Council Canada and Canada Mortgage and Housing Corporation. In 2001–2002, the Centre tested advanced integrated mechanical systems, a wastewater heat recovery system and electronically commutated motors.

Industry

Energy demand in the industrial sector – forestry, construction and mining, and all manufacturing – accounts for 39.2 percent of secondary energy use and 33.6 percent of GHG emissions.

Between 1990 and 2000, increased industrial activity resulted in a 16.3 percent increase in energy use. Over the same period, industrial GHG emissions increased by only 12.9 percent. Improvements in energy efficiency somewhat mitigated the increase. Without them, the increase in energy use would have been 25 percent higher.

NRCan's programs help industry increase energy efficiency focus on two areas: industrial processes and technologies, and equipment.

Industrial Processes and Technologies

NRCan works with industry at the association level and at the company level, encouraging and supporting industry's efforts to invest in, develop and use more energy-efficient methods and reduce GHG emissions.

In 2001–2002, 24 new companies signed on to be Industrial Energy Innovators and, in total, 126 action plans and progress reports were submitted by participants.

At the sector level, organizations that participated in NRCan's Canadian Industry Program for Energy Conservation (CIPEC) realized significant energy savings. The mean five-year increase in energy consumption for non-participants was 5.2 percent, whereas the increase registered by CIPEC participants was only 2.2 percent.

NRCan also helps industry develop cleaner, more energy-efficient combustion processes. The focus of the research is to optimize the performance of stationary combustion equipment and to develop and evaluate new products, fuels and retrofit technologies.

In 2001–2002, a series of tests was completed on an environmentally benign way of destroying PCB-laden tarry sludge from the tar ponds in Sydney, Nova Scotia.

Since 1991, NRCan has contributed $19 million to 105 projects worth $143 million to support the identification and demonstration of new and emerging energy-efficient technologies.

In 2001–2002, projects included the demonstration of water filtration technology by ZENON Environmental Inc. that uses 80 percent less energy than conventional methods. And Westport Research Inc. undertook a one-year field trial of a low-emissions natural gas engine.

Equipment

Through regulation, standards setting, labelling and research support, four NRCan programs work to improve the energy efficiency of equipment used in industry.

Presently, 50 percent of products used in this sector are covered by Energy Efficiency Standards and Regulations, which set minimum performance standards for equipment. The EnerGuide for Industry program promotes and encourages the manufacture, purchase and use of industrial equipment that is more energy efficient.

In another area, NRCan works to reduce the hazards of mining while increasing energy efficiency. In 2001–2002, testing indicated that the benefits of the new rockdrill include drilling of holes twice as quickly, reduced vibration, dust and noise (15 decibels quieter) and the elimination of oil mist emissions.

Transportation

The transportation sector accounts for more than 28 percent of secondary energy use and more than 34.5 percent of GHG emissions. Passenger and freight, two of the transportation subsectors, account for 56.7 and 39.7 percent, respectively, of transportation energy use. A third subsector, off-road, accounts for the remaining 3.6 percent.

Despite a significant growth in activity variables – primarily increased population and economic activity – transportation energy use increased by just over 21.5 percent between 1990 and 2000. Without improvements in energy efficiency, that increase would have been 39.9 percent.

In 2000, road transport was the biggest user of energy at 77.3 percent. Passenger energy use accounted for 59.7 percent of road transportation and freight energy, 40.3 percent. Because of this extremely high percentage, all NRCan transportation energy-use programs focus on the energy used in road transportation. The programs target four subgroups: personal vehicles, commercial fleets, transportation technology research and development, and alternative transportation fuels.

Personal Vehicles

NRCan's programs encourage manufacturers to meet standards for fuel consumption and improve vehicle fuel efficiency through advancements in technology. Private motorists are encouraged to purchase energy-efficient vehicles. Under a voluntary agreement, manufacturers attach an EnerGuide fuel consumption guide to their cars so that purchasers can make an informed buying decision.

The percentage of new vehicles on car lots with EnerGuide labels increased from 64 percent in 1999 to 77 percent in 2001. In dealership showrooms over the same period, the percentage rose from 47 to 56. In addition, Volvo Cars of Canada was recruited to the EnerGuide for Vehicles program, and all of the companies already involved in the program remained.

Commercial Fleets

In partnership with fleet and industry associations and other levels of government, NRCan delivers information materials, workshops, demonstrations and training to fleet operators to help improve fuel efficiency and encourage the use of alternative fuels in commercial and municipal fleets.

In 2001–2002, NRCan reached an agreement with the Canadian Association of Motive Power Educators for the delivery of the "Fuel Management 101" workshop and development of a data collection strategy to help fleets determine their fuel efficiency and GHG emissions baseline.

Transportation Technology Research and Development

NRCan supports transportation technology research and development on improving vehicle energy efficiency and reducing GHG emissions. Research is underway into the development of low-density and/or high-strength materials for use in transportation applications and of hydrogen fuel cell power to replace diesel in underground mining.

Several coatings for lightweight aluminum heat exchangers were tested. With favourable initial results, testing of heat exchanger prototypes will take place during 2002–2003.

In the mining industry, a prototype locomotive propelled with hydrogen fuel cells (the only one of its kind) has been undergoing surface testing by NRCan since the beginning of 2002.

Alternative Transportation Fuels

NRCan promotes the use and development of alternative fuels – ethanol, natural gas and fuel cells – to minimize environmental impacts.

The estimated amount of fuel ethanol blended into motor gasoline in Canada per year reached 240 million litres in 2001.

The Canadian Transportation Fuel Cell Alliance was launched to develop the fuelling infrastructure for fuel cell vehicles.

Renewable Energy

Renewable energy includes the well-established hydroelectricity industry, which accounts for approximately 58 percent of total electricity generation in Canada. But there are a number of other renewable energy sources and technologies that are emerging in the marketplace or are in development, and these show promise for the long term. NRCan delivers several initiatives to encourage their development and use. Together, all sources of renewable electricity generation reached 68 849 petajoules in 1999, or 62 percent of total capacity.

NRCan's initiatives support education and promotion programs for industry and the public, the development of standards and research. They also provide financial incentives for capacity-building in renewable energy.

Renewable Energy Programs

The Photovoltaic and Hybrid Systems Program has contributed to an average growth in solar photovoltaic applications of 25 percent per year over the last eight years. Installed power capacity in Canada reached 8.1 megawatts in 2001.

In 2001–2002, NRCan contributed more than $1.2 million to 49 projects that were completed under the Renewable Energy Deployment Initiative.

NRCan has also pledged to purchase 20 percent of its electricity from new green power sources by 2010, wherever it makes economic sense.

The Renewable Energy Capacity-Building Program team received the 2001 Head of the Public Service Award for Excellence in Service Delivery. The Program also provided project implementation support to more than 50 potential renewable energy projects at federal and municipal government facilities and in Aboriginal and northern communities.

With ongoing support (dating back to the early 1980s) from NRCan's Renewable Energy Technologies Program, Conserval Engineering Inc. developed SOLARWALL® – the world's most efficient solar air heating system. In 2001–2002, NRCan's new 200-kilowatt indoor solar simulator lamp, the world's largest, opened for business at the National Solar Test Facility. This facility is North America's leading centre for testing and rating technologies under controlled sunlight and temperature conditions.

Community Energy Systems

Through the Community Energy Systems Program, NRCan helped design a heating system for the Cree community of Oujé-Bougoumou in northern Quebec. The system uses sawdust from a local sawmill to provide more than 90 percent of the energy. The resulting reduction in carbon dioxide emissions is estimated to be 2300 tonnes per year.

Federal House in Order

As the country's largest single enterprise, the Government of Canada is working to get its own house in order. It has set as its target a 31 percent reduction in GHG emissions from its own operations by 2010.

The Government of Canada has already achieved a 21 percent reduction since 1990, through building retrofits, better fleet management, downsizing of operations and strategic green power purchases. In 1990, emissions were 3837 kilotonnes. In 2000, emissions were down to 3031 kilotonnes. The Government of Canada will reduce its emissions by a further 12 percent by 2010.

Key departments and agencies that are responsible for 95 percent of Government of Canada GHG emissions have been assigned specific targets under a three-year action plan and must report annually on their progress.

NRCan is providing services and support to these departments and agencies to help them achieve their targets.

Federal Programs

The Federal House in Order initiative activities include GHG inventory and tracking, purchases of emerging renewable electricity, or green power, and efforts to reduce "outside emissions." Under one pilot project launched in October 2002, the opportunity to purchase a transit pass through payroll deduction and at a small discount encourages federal employees to use public transit.

In other programs, NRCan supports efforts to retrofit buildings and other facilities to improve their energy efficiency. This support includes advice and consultation, project financing options and promotion.

In 2001–2002, retrofits of 7000 federal buildings and other facilities were initiated and registered, reducing GHG emissions significantly and generating annual savings of $27 million. In just one example, as of March 2002, the Department of National Defence had invested $104 million and will save an estimated 11.8 terajoules of energy per year.

Targeting heating and cooling systems, NRCan helps federal clients increase energy efficiency, reduce carbon dioxide (CO_2) and nitrogen oxide (NO_x) emissions by encouraging the adoption of new heating and cooling technologies. These technologies could reduce NO_x emissions by 50 percent, increase energy efficiency by up to 15 percent and reduce operating costs by 20 percent, compared with conventional practices. Clients have reduced energy consumption by 800 terajoules, CO_2 emissions by 45 kilotonnes and NO_x emissions by 100 tonnes. Client departments involved in the program have realized incremental improvements in energy efficiency over each year of their involvement. From 2000–2001 to 2001–2002, energy savings as a result of this program increased by 112 terajoules per year, for a total annual savings of 812 terajoules.

Federal vehicles are also targeted under this initiative. NRCan assesses fleets and provides technical advice and encouragement on acquiring and using alternative transportation fuels. Four departments participate in planning and reporting on the initiative: Treasury Board of Canada Secretariat, NRCan, Environment Canada and Public Works and Government Services Canada.

In 2001–2002, an agreement was reached with the Canada Safety Council to include energy efficiency content in the 2002 version of the Defensive Driving Course. The Department of National Defence, the Canadian Food Inspection Agency/Agriculture and Agri-Food Canada and Correctional Service of Canada use this course for all their drivers.

TABLE 1-1

Performance Indicators Highlighted in the Report

Housing

- Average Energy Consumption per Household
- National Trends in Air Leakage in Houses
- Homes Evaluated and Labelled Under the EnerGuide for Houses Program
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- REDI for Business Projects Completed

Federal House in Order

- GHG Emissions Reductions from All Federal Operations
- FBI Investment and Energy Savings
- Energy Savings from FIBP, 1991–1992 to 2001–2002
- Federal Fleet Size and Fuel Consumption, 1995–1996 to 1999–2000
- Purchase of ATF Vehicles for the Federal Fleet

Introduction

Greenhouse Gases and Climate Change

Climate change is a global challenge arising from the continuing buildup in levels of anthropogenic (human-produced) greenhouse gases (GHGs) in the atmosphere, in addition to naturally occurring emissions. GHGs are constituted by a number of gases, but the main source of anthropogenic emissions is carbon dioxide (CO_2) from the combustion of fossil fuels. Substantially reducing GHG emissions is a challenge, particularly given Canada's highly industrialized and resource-based economy. Solutions require a multi-faceted, coordinated domestic response and a high level of cooperation among all nations.

In December 1997, Canada and more than 160 other countries met in Kyoto, Japan, and agreed to targets to reduce GHG emissions. Canada's target is to reduce its GHG emissions to 6 percent below 1990 levels by the first commitment period (2008 to 2012).

After signing the Kyoto Protocol, Canada established a National Climate Change Process with provinces, territories, stakeholders and the Canadian public to examine the potential impacts, costs and benefits of the protocol and possible options for its implementation. Currently, the Government of Canada is facilitating comprehensive analytical work and full discussions on these options.

The *Government of Canada Action Plan 2000 on Climate Change* (Action Plan 2000) comprises policies and measures that have significantly increased the scope of funding and activity in the key areas of energy efficiency, technology development and the promotion of alternative energy sources. Announced in October 2000, the Action Plan measures were implemented during 2001–2002.

Natural Resources Canada's Efficiency and Alternative Energy Program

Over the past decade, Natural Resources Canada's (NRCan's) emphasis has been to promote energy efficiency and the use of alternative energy as a means to reduce GHG emissions, particularly in relation to the Kyoto Protocol. Improving energy efficiency reduces greenhouse gas emissions that contribute to climate change. NRCan's Efficiency and Alternative Energy (EAE) program was launched in 1991. A complete list of NRCan's EAE initiatives and expenditures in 2001–2002 are listed in Appendix 1. These initiatives engage Canadian society and all major sectors of the economy in new and more efficient approaches to secondary energy use – i.e., the consumption of energy in the residential, commercial and institutional, industrial and transportation sectors.

NRCan's EAE initiatives are managed by

- the Office of Energy Efficiency (OEE), which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels;
- the CANMET Energy Technology Centre[1] and the Mineral Technology Branch, which deliver EAE research and development (R&D) initiatives;
- the Energy Resources Branch, which delivers market transformation initiatives for renewable energy; and
- the Science Branch of the Canadian Forest Service, which undertakes R&D in the use of forest biomass for energy.

[1] CANMET is the Canada Centre for Mineral and Energy Technology.

In its efforts to reduce GHG emissions, NRCan emphasizes partnership and cooperation with stakeholders such as other levels of government, the private sector and non-governmental organizations. Using this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side, Canada participates in developing technology for tapping renewable energy resources and alternative transportation fuels as well as increasing the energy efficiency of production.

In This Report

This ninth annual Report to Parliament focuses principally on EAE initiatives that address secondary energy use. Chapter 1 provides the policy context and strategic overview. Trends in energy use and GHG emissions in Canada are discussed in Chapter 2. Chapter 3 summarizes work undertaken during the reporting period to improve the quality and coverage of performance indicators for the initiatives described in Chapters 4 through 9. Chapters 4 to 7 review individual EAE initiatives to improve energy use in housing, buildings, industry and transportation, highlighting their achievements and progress indicators. Chapter 8 deals with renewable energy sources and use as well as an initiative in energy efficiency and renewable energy in Canadian communities. Chapter 9 describes the Government of Canada's actions to improve its own use of energy. The final chapter describes intergovernmental cooperation in EAE.

Chapter 1: Policy Context and Legislation

Federal Policy and Programs on Energy Efficiency and Alternative Energy

Energy use has been a policy concern since the 1970s when governments responded to the oil crises of 1973 and 1979 by promoting energy conservation and renewable energy sources. By the mid-1980s, world oil supply had become sufficiently abundant that governments deregulated energy prices and markets and phased out most energy conservation and renewable energy programs.

Toward the end of the 1980s, individuals, organizations and governments around the world became concerned that greenhouse gas (GHG) emissions produced by burning fossil fuels – such as coal, oil and natural gas – could contribute to climate change.

In 1990, Canada's concern about its GHG emissions (which result mostly from energy use) spurred an expansion of federal programs designed to improve energy efficiency and increase the use of alternative energy sources. The ongoing Efficiency and Alternative Energy (EAE) program was launched by Natural Resources Canada (NRCan) in 1991 to support economically feasible improvements in energy efficiency and the use of alternative energy sources. It encourages investment in corporate and consumer EAE opportunities and seeks to engage all sectors of the economy and Canadian society in rethinking and improving energy use. The EAE program uses a variety of policy instruments, including leadership, information, voluntary actions, financial incentives, research and development (R&D) and regulation. In all cases, it emphasizes partnership with stakeholders, such as other levels of government, the private sector and non-governmental organizations.

In this manner, the program helps the demand side of the energy market move toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side of the market, the program ensures that Canada participates in the development of technology for tapping renewable energy sources, using alternative transportation fuels and increasing the energy efficiency of the production of energy.

The EAE program has provided a foundation for long-term processes that respond to evolving environmental and economic development priorities. Since 1991, a number of major developments have affected NRCan's EAE policies and programs.

In 1992, Canada signed and ratified the *United Nations Framework Convention on Climate Change*. Under this convention, Canada and other countries agreed to work to stabilize GHG emissions at 1990 levels by 2000. In 1995, federal and provincial ministers of energy and the environment approved the National Action Program on Climate Change (NAPCC), which included as a key strategic element the promotion of energy efficiency in all sectors of the economy. At the same time, to broaden awareness of the need to act and reinforce the impetus to voluntary action, they also agreed to establish the Climate Change Voluntary Challenge and Registry (VCR). It was incorporated in October 1997 as a non-governmental, not-for-profit organization. Canada's Climate Change Voluntary Challenge and Registry Inc. (VCR Inc.) invites Canadian companies and organizations to develop action plans to limit their net GHG emissions and to file these, as well as progress reports and achievements, on its public registry.

The federal budget of February 1997 provided $60 million over three years for new initiatives to improve energy efficiency in new commercial buildings; encourage commercial building retrofits; provide for energy performance assessments of houses; and stimulate demand for cost-effective, commercially available renewable energy systems for space and water heating and cooling. This funding was renewed in the February 2000 federal budget.

In December 1997, at the third Conference of the Parties to the Framework Convention on Climate Change held in Kyoto, Japan, participating countries agreed to reduce GHG emissions from 1990 levels within the period 2008 to 2012. Canada pledged to reduce its emissions by 6 percent. The protocol will enter into force when at least 55 parties to the Framework Convention, representing 55 percent of industrialized countries' GHG emissions, have ratified it.

In February 1998, the federal budget provided $150 million over three years for a Climate Change Action Fund (CCAF) to help Canada develop its response to the Kyoto Protocol. This funding was renewed in the February 2000 federal budget. The fund has the following four components:

- *Public Education and Outreach* builds public awareness and understanding of climate change and encourages action to reduce GHG emissions;
- *Technology Early Action Measures* (TEAM) shares with the private sector the risk of demonstrating cost-effective technology projects that will lead to reductions in GHG emissions;
- *Science, Impacts and Adaptation* supports research to advance our knowledge of the magnitude, rate and regional distribution of the impacts of climate change on Canada and supports the development of adaptation strategies; and
- *Foundation Analysis* supports the National Climate Change Process and the analysis of options for reducing Canada's GHG emissions.

In early 1998, the federal, provincial and territorial governments established the National Climate Change Process to examine the impact, costs and benefits of the Kyoto Protocol and the implementation options open to Canada. From spring 1998 to winter 1999–2000, the process engaged more than 450 experts from across Canada, and their recommendations were provided to governments in fall 2000. During the reporting period, the Government of Canada issued the *Discussion Paper on Canada's Contribution to Addressing Climate Change* and commenced consultations with stakeholders. NRCan officials have provided a great deal of support, analysis, advice and guidance to the National Climate Change Process.

In January 2000, federal, provincial and territorial ministers of energy and the environment announced the Baseline Protection Initiative (BPI) as one of the first major policy initiatives to be taken under Canada's National Implementation Strategy on Climate Change. It is designed to remove possible disincentives to early actions to reduce GHG emissions by allowing organizations to reconstruct their emissions baselines to reflect the impact of actions taken since January 1, 1990.

In addition to the previously noted renewal of funding for four EAE initiatives and the CCAF, the federal 2000 budget also provided funds for a Green Municipal Enabling Fund (GMEF) and a Green Municipal Investment Fund (GMIF). The Federation of Canadian Municipalities manages the two funds under agreements with NRCan and Environment Canada. The GMEF is a $25-million endowment, available for five years, to contribute to feasibility studies of energy and environmental projects in municipal operations. The GMIF is a permanent, $100-million endowment to provide loans and loan guarantees to eligible recipients to carry out energy and environmental projects. It also provides grants and long-term loans for pilot projects that demonstrate innovative technologies and processes.

Building on a successful initial purchase of green power in Alberta, the February 2000 federal budget expanded the pilot initiative to permit the procurement of $15 million in renewable energy over the next 10 years for federal facilities in Saskatchewan and Prince Edward Island.

In October 2000, the Government of Canada announced its *Action Plan 2000 on Climate Change*, representing its contribution to *Canada's First National Climate Change Business Plan* being developed with the provinces and territories. Funding of $500 million over five years began in 2000–2001.

Responsibility

In April 1998, NRCan's Office of Energy Efficiency (OEE) was established, with a mandate to strengthen and expand Canada's commitment to energy efficiency, in particular to help address the challenges of climate change. The OEE's programs target all final energy consumers and emphasize partnerships and economic investment. Its program objectives are to overcome the market barriers posed by inadequate information and knowledge about energy efficiency and alternative transportation fuels, and to address institutional deterrents in energy-use markets and economic constraints that energy users face. The OEE is also responsible for identifying opportunities for new and heightened energy efficiency measures. The National Advisory Council on Energy Efficiency assists in this work by providing advice and guidance to the OEE. The council comprises energy efficiency experts and leaders from all sectors of the economy.

NRCan's Office of Energy Research and Development (OERD) coordinates and funds non-nuclear, energy-related R&D for the Government of Canada in partnership with 12 federal departments and agencies. As a response to climate change, the OERD, through the Program of Energy Research and Development (PERD), dedicates more than 50 percent of its annual $58-million R&D budget to study options related to energy efficiency and alternative energy. In addition, PERD directs funding toward studies aimed at understanding climate change and developing mitigation or adaptation options related to it.

NRCan's CANMET Energy Technology Centre (CETC) focuses on technology development and deployment. Technology development activities are performed on a cost-shared basis either through in-house R&D work at its laboratories or by providing funding support to its technology partners. CETC-Ottawa, in Ontario, works in partnership with a range of stakeholders to develop and disseminate innovative, cleaner energy technologies, including energy-efficient technologies for homes, businesses and industry; renewable energy; alternative transportation fuels; district heating and cooling systems; advanced low-emissions combustion technologies; and energy-efficient metallurgical fuel products and technologies. CETC-Varennes, in Quebec, develops technologies that use energy wisely and help Canadians stay competitive in the marketplace, such as advanced drying technologies, heat transfer and storage systems, photovoltaics, renewable energy for remote communities and related software tools such as RETScreen® International.

The Energy Resources Branch (ERB) is the fourth organization within NRCan's Energy Sector reporting on programs in this document. Within the ERB, the Renewable and Electrical Energy Division promotes the development of a sustainable renewable energy industry in Canada. It promotes investments in renewable energy systems for heating and cooling and provides information on renewable energy technologies. By strengthening markets for the renewable energy industry, its programs contribute to GHG reductions, job creation and export sales.

Energy Efficiency Strategy

Most of NRCan's EAE initiatives deal solely with energy efficiency. Their goal is to improve energy efficiency by

- increasing the energy efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to purchase buildings, equipment, systems and vehicles that are more energy efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way;
- influencing the energy-use practices of individuals and organizations; and
- developing technologies to give consumers, industry and communities new opportunities to improve energy efficiency.

Alternative Energy Strategy

In the short term, energy efficiency improvements can contribute significantly to energy savings and environmental objectives. In the long term, however, reducing GHG emissions to 1990 levels or below will require greater use of alternative energy sources.

Alternative energy includes renewable sources other than large hydro-electric facilities, new applications of conventional sources and new fuels such as hydrogen for fuel cells. (Large hydro is not considered an alternative energy source because it is already a successful, well-established mode of energy production, supplying more than 60 percent of the electricity in Canada.) Some technologies, especially those that involve the use of forestry biomass and propane and natural gas in vehicles, are already commercially available and accepted. Some have found applications in specialized markets, such as remote communities. Other technologies are still in the early stages of development.

Federal initiatives are helping to expand the infrastructure (e.g., fuelling stations) for the sale of alternative transportation fuels, especially in urban areas where the provision of infrastructure is more economic. R&D focuses on ways to improve options in the use of these fuels.

NRCan supports R&D to reduce costs, improve performance, develop safety and performance standards and increase the scope of renewable energy technologies. The department also provides incentives for investments in renewable energy systems and purchases of electricity generated from renewable sources, disseminates information to consumers, and assesses economic and environmental aspects of renewable sources of energy.

Policy Instruments

NRCan's key policy instruments are

- leadership;
- information;
- voluntary initiatives;
- financial incentives;
- regulation; and
- research and development.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing the energy efficiency and use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates information to consumers, using methods that range from broad distribution to individual consultations with clients. These activities include publications, exhibits, advertising, toll-free lines, conferences, Web sites, workshops and promotional products. NRCan's wide range of marketing and communications activities aim to

- increase awareness among Canadians of the environmental impact of energy use; and
- encourage consumers to increase the efficiency of their energy use and to switch to alternative sources of energy.

Voluntary Initiatives

Companies and institutions work with NRCan on a voluntary basis to establish and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target large consumers of energy in the commercial, institutional and industrial sectors and organizations whose products are important determinants of energy use. In a typical initiative, an organization agrees to take steps that will save money and reduce environmental impacts. The initiatives involve industry-government

agreements and, for groups of large industrial energy users, energy efficiency target setting. NRCan provides a variety of support services to assist and stimulate action by companies and institutions on energy efficiency, including developing standards and training.

Financial Incentives

NRCan uses financial incentives to encourage final users of energy to employ energy efficiency and renewable energy technologies and practices when they acquire, design or build new buildings or retrofit existing ones. NRCan also offers financial incentives for wind energy and for natural gas vehicles and refuelling infrastructure.

Regulation

Regulation involves setting energy performance levels and labelling requirements for certain types of equipment and working with provincial governments to improve the energy efficiency provisions in Canadian building codes.

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations concerning EAE, primarily performance and labelling requirements for energy-using products (as well as doors and windows) that are imported or shipped from province to province. The Act also gives the Government of Canada the authority to establish regulations and to collect statistics and information on energy use and alternative energy.

Research and Development

NRCan's EAE initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. R&D also provides the scientific knowledge needed to develop the technologies, codes, standards and regulations required for the sustainable use of energy.

FIGURE 1-1

Moving the Market

NRCan provides national leadership in energy science and technology (S&T) by undertaking in-house research in its own laboratories, by contracting out research activities to other organizations and through the federal PERD. PERD and TEAM are the only federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

Figure 1-1 shows how these policy tools work together to increase energy efficiency, i.e., how they help to reduce the amount of energy needed to obtain a certain level of service.

Chapter 2: Trends in Energy Use

Introduction

Canadians enjoy an abundance of energy from a variety of sources. This comparative advantage in the supply of energy has helped Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. It also has favoured the development of industries that have a particularly strong energy demand. As a result, Canada consumes more energy per capita than most countries.

Canadians spend almost $104 billion per year on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes. This represents almost 10 percent of the country's gross domestic product.

Energy Use and Greenhouse Gas Emissions

We typically speak of two types of energy use: primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (e.g., coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use is energy used by final consumers for residential, agricultural, commercial, industrial and transportation purposes.

Primary energy use in Canada today reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. Primary energy use increased by more than 19.5 percent between 1990 and 2000, from 9724 petajoules to 11 621 petajoules.

Secondary energy use (8164 petajoules) accounted for 70.3 percent of primary energy use in 2000. It was responsible for about 65.6 percent (474 megatonnes) of total greenhouse gas (GHG) emissions in Canada, if we include indirect emissions – namely, those produced by electric utilities to meet end-use electrical demand.

This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane and nitrous oxide. CO_2 represents the majority of Canada's GHG emissions. All subsequent references in this report to CO_2 and GHGs include both emissions that are attributable directly to secondary energy use and indirect emissions attributable to electricity generation.

From 1990 to 2000, secondary energy use increased by 16.7 percent. GHG emissions attributable to secondary energy use increased by only 16.3 percent because of a 0.3 percent decrease in the GHG intensity of energy users. This reflects changes in the fuel mix. By 2000, the oil share of secondary energy use had fallen by 1.2 percentage points from 1990 levels, from 41.2 to 40.0 percent, and the natural gas share increased from 25.4 to 26.1 percent. The electricity share was stable, and the share of other fuels, mainly biomass, increased.

The industrial sector is the largest energy user, accounting for 39.2 percent of total secondary energy use in 2000. The transportation sector is the second-largest energy user at 28.0 percent, followed by the residential sector at 17.0 percent, the commercial and institutional sector at 13.0 percent and the agriculture sector at 2.8 percent.

Energy Efficiency

NRCan annually publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use (and GHG emissions) since 1990 and the contribution of the following key factors to these changes:

- increases in sector *activity* lead to increased energy use and emissions. In the residential sector, for example, an increase in the number of households has the effect of increasing energy use;
- a shift in the *structure* of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter;
- fluctuations in *weather* lead to changes in space-heating and cooling requirements. A colder winter or a warmer summer can lead to increased energy use; and
- *energy efficiency* – the amount of energy used to provide a given level of service.

In this report, changes in energy efficiency are the net result after allowing for the changes in energy use due to changes in activity, structure and weather. To the extent that other factors that affect energy use have not been captured, this measure of energy efficiency improvement might overstate or understate the "actual" change. For example, in the industrial sector, there may have been changes in energy use due to shifts in the mix of products, but this is not captured.

Secondary energy use increased by 16.7 percent between 1990 and 2000 (from 6999 to 8164 petajoules). Two factors contributed to this increase (see Table 2-1):

- activity (economic growth) raised secondary energy use by 26.4 percent (1845 petajoules); and
- changes in the structure of activity decreased secondary energy use by 1.5 percent (108 petajoules).

A third factor – weather – increased secondary energy use by 0.6 percent (40 petajoules), reflecting the extent to which the winter of 2000 was colder than the winter of 1990.

If only these three factors had been in effect, secondary energy use would have increased by 25.4 percent. However, improvements in energy efficiency worked to decrease energy use by 9.4 percent (661 petajoules).

TABLE 2-1

Explanation of Changes in Secondary Energy Use, 1990 to 2000

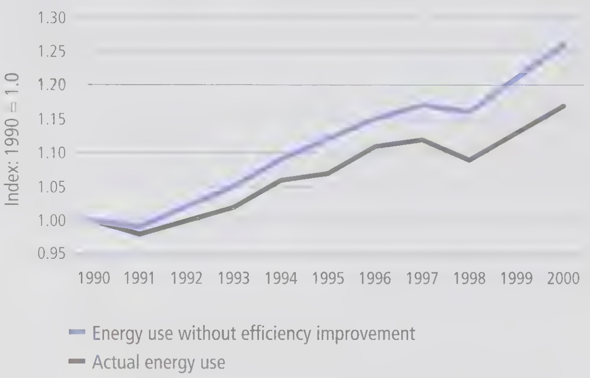
	Sectors						
	Residential	Commercial-Institutional	Industrial	Transportation	Agriculture	Total	% Change
1990 energy use (PJ)	1300	867	2755	1878	199	6999	
2000 energy use (PJ)	1388	1059	3204	2282	232	8164	
Change in energy use (PJ)	88	192	449	404	33	1166	16.7
Explanatory Factor (change due to)							
Activity	224.7	205.4	1004.7	410.3		1845.1	26.4
Structure	28.6	2.9	-316.7	177.5		-107.7	-1.5
Weather	31.6	8.3	N/A	N/A		39.9	0.6
Energy efficiency (PJ)	-196.6	-23.2	-239.2	-201.9	0	-660.8	-9.4
Other factors		-1.6		18.3	32.8	49.5	0.7

As a result, energy use increased by only 16.7 percent. This change in energy use during 1990–2000, with and without changes in energy efficiency, is shown in Figure 2-1. The difference in energy use due to energy efficiency – the energy saving – represents a reduction in energy costs of $8.7 billion a year and a reduction in GHG emissions of over 38 megatonnes.

Changes in energy efficiency are estimated for each of the four major end-use sectors and presented in Chapters 4 to 7. The energy efficiency improvements were largest in the residential sector (15.1 percent), followed by the transportation (11.3 percent), industrial (8.7 percent) and commercial and institutional sectors (2.7 percent).[2]

FIGURE 2-1

Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000



Renewable Energy

As previously noted, changes in the fuel mix employed by the Canadian economy can reduce GHG intensity. Although in the near term this can be achieved by moving from more- to less-GHG-intensive fuels (e.g., from coal to natural gas), over the longer term the use of renewable energy sources is expected to accelerate this trend.

Figure 2-2 shows the trend in the use in Canada of electricity generated from wind, solar and biomass, indicating a 140 percent increase over the period 1991 to 2000. Although representing only a small component of overall electricity use, the proportion of electricity generated from these renewable energy sources increased from 1.1 to 1.6 percent over the period, representing a 45 percent increase in its share. Most of this production was derived from biomass.

The graph does not include hydro sources, either conventional or small (less than 20 megawatts). The former accounts for about 60 percent of electricity generated in Canada; installed capacity is over 67 gigawatts. There are over 230 small hydro installations in Canada, with a total capacity of about 1500 megawatts.

FIGURE 2-2

Net Solar, Wind, Wood and Waste Electric Power Consumption in Canada

[2] The aggregate energy-use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for the purpose of energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix A of Natural Resources Canada's *End-Use Energy Data Handbook 1990–2000.*

Chapter 3: Measuring Progress

Background

The primary goal of Natural Resources Canada's (NRCan's) Efficiency and Alternative Energy (EAE) initiatives is to change energy consumption patterns to obtain environmental and economic benefits. Part of assessing program progress and program performance involves considering program delivery and program effectiveness.

In the past, NRCan has focused on the monitoring and tracking of the following three aspects of program delivery:

- program outputs;
- program outcomes; and
- market outcomes.

Program outputs are the items that a program produces regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. Program outputs are designed to lead to *program outcomes* – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase appliances that are more energy efficient than they would have purchased if there had been no program. Other important factors that influence consumer behaviour include product price, household income, personal taste and other government and non-government programs.

Because program outcomes can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable *market outcomes*. Market outcomes ultimately reflect the impacts of NRCan programs on changes in energy efficiency, energy intensity, greenhouse gas (GHG) emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress toward a market outcome, serves as an indicator of program effectiveness. An example of a program outcome that leads to a market outcome is a householder's purchase of a more energy-efficient appliance and reduced use of electricity. Depending on the source of electricity, and how the utility changes its electricity-generating methods to meet the change in demand that results from reduced electricity use, this could also lead to a decline in GHG emissions.

A Renewed Focus on Results

More recently, a government-wide initiative aimed at "managing for results" has encouraged management in all federal departments and agencies to focus more on the impacts and effects of their programs and services on the lives of Canadians. Managing for results requires more than just monitoring program delivery; it means clearly defining the results to be achieved, an increased emphasis on program and market outcomes, measuring and evaluating program performance and making adjustments to improve both the efficiency and effectiveness of programs. It also means reporting on performance in ways that make sense to Canadians.

Measuring program and market outcomes can be time-consuming, costly and difficult. In particular, quantifying program outcomes requires client and data surveys and detailed analyses of energy use. NRCan's National Energy Use Database (NEUD) initiative helps the department track changes in energy consumption at a disaggregated level. Still, it is difficult to determine the incremental effects of programs because other factors, such as variation in energy prices, also influence these effects. Moreover, because several factors and programs can influence a consumer at the same time, it is difficult to determine the separate contribution of each factor and program to the total effect. Consequently, quantifying program outcomes, impacts and, ultimately, results also requires some knowledge of attribution – or the proportion of the observed or estimated market outcome that can be reasonably attributed solely to program activities and efforts.

This report uses a mix of progress indicators, which are quantitative where possible. The challenge for NRCan is to continuously improve the coverage and quality of these progress indicators, both in general and to ensure that they increasingly reflect a focus on results. The following page highlights some of NRCan's more recent and current efforts to improve the quality of its program performance information.

2001–2002 Highlights of the Office of Energy Efficiency's Program Attribution Research

In the last year, the Office of Energy Efficiency (OEE) completed impact attribution studies for two of its programs – the Canadian Industry Program for Energy Conservation (CIPEC) and EnerGuide for Equipment. Both of these studies employed analytical methods derived from discrete choice theory, which the private sector has used to estimate the change in behaviour that can occur (for either an individual or a group of individuals) as a result of a firm's marketing efforts or a utility's program efforts. Discrete choice theory methods are only beginning to be applied to the evaluation of public sector programs. Both studies were aimed at estimating the market outcomes of the programs, measured in terms of energy savings and GHG emissions reductions that could be attributed solely to program efforts. The studies yielded positive and insightful results that not only allow managers to gauge the effectiveness of their programs, but also allow the programs to be strategically improved to ensure even better outcomes in the future.

The CIPEC study revealed that the average five-year increase in energy consumption, adjusted for extraneous factors such as weather, changes in business size and production, was 2.4 times lower for program participants than for non-participants. The impact of the program was even greater for specific energy-using systems. For example, program participants experienced no net change in the adjusted five-year average energy consumption of their boiler systems, whereas CIPEC non-participants saw the adjusted five-year average energy consumption of their boiler systems increase by almost 7 percent. Refer to Chapter 6 for more highlights of CIPEC's recent achievements.

The EnerGuide for Equipment study also showed that the program was having a positive impact on its target market. More specifically, the study revealed that the presence of the EnerGuide label helped sell more higher-efficiency residential appliances between 1990 and 2000 than would otherwise have been sold in the absence of program efforts. Estimated electricity savings and GHG emissions reductions due to the labelling program total about 530 gigawatt hours per year and 288 kilotonnes of GHGs, respectively, for the period 1990 to 2000. Refer to Chapters 4 to 7 for more study results and more highlights of this program's recent achievements.

The OEE is now undertaking further analysis to determine the impacts of its other programs and anticipates completing at least two more similar studies in the coming fiscal year. The OEE will continue to report on the progress of its performance assessment work in the coming years.

Chapter 4: Housing

Energy Use and Greenhouse Gas Emissions

The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling, heating water and operating appliances and lights. This sector accounts for 17.0 percent (1388 petajoules) of secondary energy use and 15.8 percent (75 megatonnes) of greenhouse gas (GHG) emissions.

Most dwellings in Canada are single detached houses, followed by apartments, single attached dwellings and mobile homes (see Figure 4-1). Because single detached and attached houses predominate, most Natural Resources Canada (NRCan) residential building programs focus on these dwellings.

Space and water heating make up 81.6 percent of residential energy use, followed by the shares devoted to operating appliances, lighting and space cooling (see Figure 4-2).

Between 1990 and 2000, residential energy use increased by 6.8 percent, or 88 petajoules (from 1300 to 1388 petajoules). From 1990 to 2000, GHG emissions from the residential sector increased by 7.3 percent. A 6.8 percent increase in energy use combined with a 7.3 percent increase in GHG emissions reflects an increase in GHG intensity. This was principally due to an increase in the carbon intensity of electricity.

Four main factors tended to influence residential energy use – activity, weather, structure and energy efficiency:

- activity – the increase in the number of households and the size of dwellings (the principal measures of residential activity) increased energy use by 17.3 percent (225 petajoules);
- weather – colder weather in 2000 compared with 1990 led to an increase in space-heating requirements. This increased energy use by 2.4 percent (32 petajoules);
- structure – the percentage shares of energy end-uses changed over the period such that they increased energy use by 2.2 percent (29 petajoules); and
- energy efficiency – improvements in energy efficiency worked to decrease energy use by 15.1 percent (197 petajoules).

FIGURE 4-1

Canadian Households by Type of Dwelling, 2000

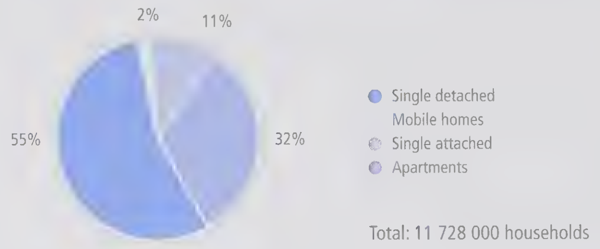
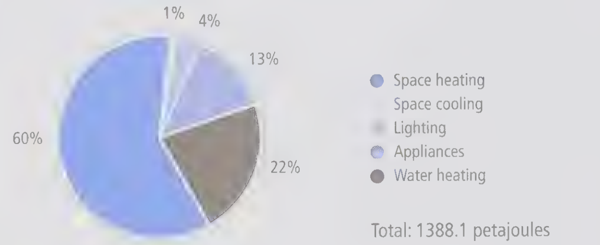


FIGURE 4-2

Residential Energy Use by Purpose, 2000



Growth in residential energy use was driven in large part by growth in activity. This increase was partially offset by significant improvements in energy efficiency. Structural changes had a minor impact on residential energy use.

The change in residential energy use from the years 1990 to 2000, as well as the energy savings due to energy efficiency, is shown in Figure 4-3.

NRCan delivers initiatives to increase energy efficiency in the following residential subsectors:

- new houses;
- existing houses; and
- residential equipment, including
  - energy performance regulations; and
  - energy labelling.

FIGURE 4-3

Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000

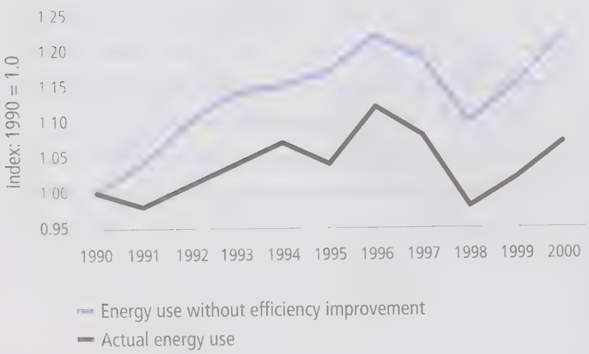
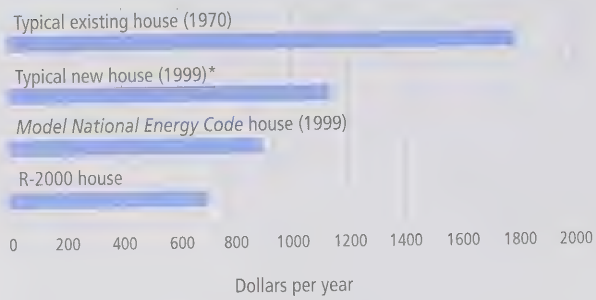


FIGURE 4-4

Annual Heating Costs for Houses Constructed to Different Standards, 1999



*198-m^2 single detached house heated with natural gas, Ottawa, Ontario.

FIGURE 4-5

Average Energy Consumption per Household (EnerGuide for Houses Program and R-2000 Initiative)

New Houses: R-2000* Standard

Objective: To increase market adoption of energy-efficient new houses by promoting changes in construction practices.

The R-2000 Initiative encourages Canadians to build houses that are more energy efficient and that are environmentally friendly and healthy to live in. Trained and licensed R-2000 homebuilders and other professionals commit to meeting the R-2000 Standard – a technical performance standard that exceeds the requirements for energy efficiency and environmental responsibility in current Canadian building codes.

Key 2001–2002 Achievements

- 100 percent of the 140 active builders and over 20 new builders and professionals were trained to the revised R-2000 Standard.

For more information:
oee.nrcan.gc.ca/r-2000/english/index.cfm

*R-2000 is an official mark of Natural Resources Canada.

FIGURE 4-6

R-2000 Share of National Housing Completions, 1990 to 2000

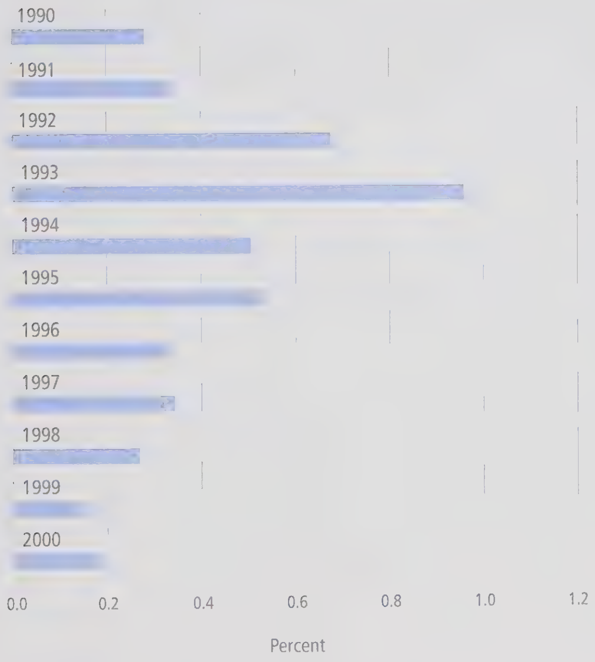
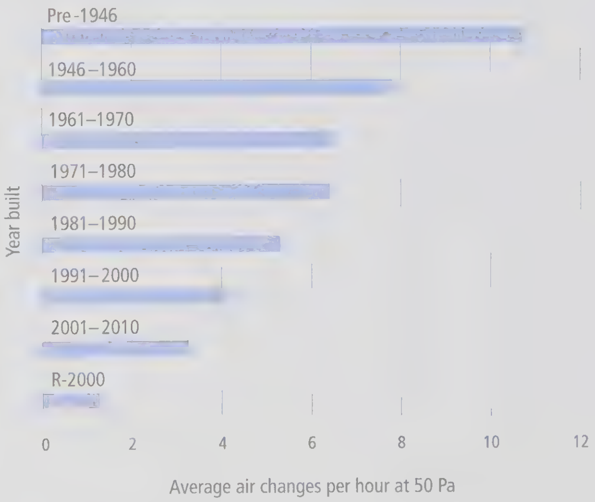


FIGURE 4-7

National Trends in Air Leakage in Houses



New Houses: Super E™ Program

Objective: To export energy-efficient, durable and environmentally friendly Canadian housing technology to foreign builders.

The Super E™ Program is a strategic housing export initiative delivered by NRCan as part of the Team Canada export strategy. Launched in 1998, the Super E™ initiative involves partnerships between government and industry. The first Super E™ houses were built in Japan.

- The Canadian R-2000 housing concept has been adapted to international markets through Super E™ and now has broad acceptance. To date, in Japan, 54 houses have been built; in the United Kingdom, one is complete and 31 are under construction.
- Over 15 Canadian companies from British Columbia to Prince Edward Island are partnered with over 40 foreign companies in Japan and the United Kingdom.

Key 2001–2002 Achievements

- Working with a Canadian builder, a U.K. builder and the Canada Mortgage and Housing Corporation, the Super E™ program was brought to the United Kingdom, and the first house opened. Additional partnerships between Canadian and U.K. interests in England, Scotland and Ireland are underway. The Super E™ U.K. initiative resulted in the establishment of a partnership with Zurich Insurance Company of the United Kingdom.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Existing Houses: EnerGuide for Houses

Objective: To encourage Canadians to improve the energy efficiency of their homes.

The EnerGuide for Houses Program provides Canadians with the facts they need to improve the energy efficiency of their homes, especially when undertaking home renovation and maintenance projects. The program offers homeowners personalized expert advice on how to improve the energy performance of their houses.

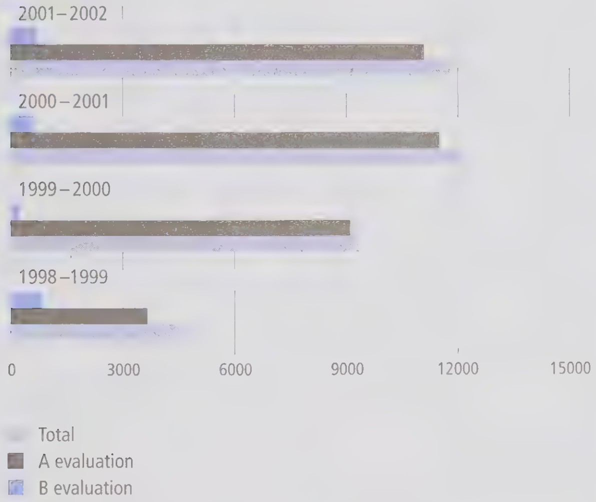
Key 2001–2002 Achievements

- NRCan signed contracts with 15 delivery agents to cover 80 percent of the Canadian population.
- Average annual energy savings for homes that underwent some retrofit activities was 17.6 percent.

For more information:
oee.nrcan.gc.ca/houses-maisons

FIGURE 4-8

Homes Evaluated and Labelled Under the EnerGuide for Houses Program



Under the EnerGuide for Houses Program, homes are evaluated to determine the potential for energy savings (an A evaluation). After renovations implementing program recommendations have taken place, some homes are revisited to determine the actual energy savings (a B evaluation).

FIGURE 4-9

Residential Energy Use and Energy Savings per Household

Residential Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy-performance levels and labelling requirements.

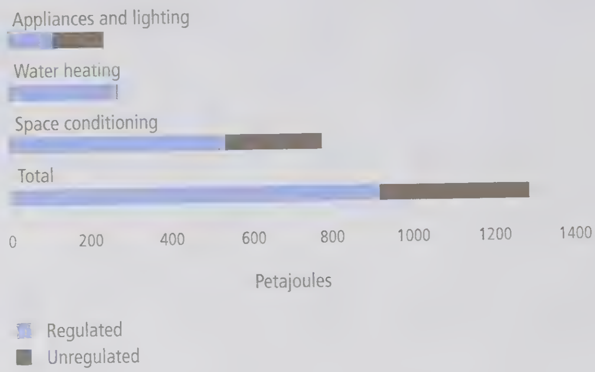
Key 2001–2002 Achievements

- The Regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial-institutional sector.

For more information:
oee.nrcan.gc.ca/regulations

FIGURE 4-10

Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 1999



Residential Equipment: Labelling and Promotion

Objective: To promote the production, purchase and use of more energy-efficient major electrical household appliances, as well as heating, ventilating and air-conditioning (HVAC) equipment.

The Labelling and Promotion program uses labelling, rating and promotional activities to encourage manufacturers to produce, and consumers to purchase and use, more efficient energy-using equipment. The program is made up of EnerGuide for Equipment, which provides comparative information on the energy performance of major household appliances and HVAC equipment, and the Energy Star® initiative, which allows the consumer to identify the most energy-efficient products available based on a standard set of criteria.

Key 2001–2002 Achievements

- Over 32 energy-using products are regulated for their minimum energy performance.

For more information:
oee.nrcan.gc.ca/energuide
or
oee.nrcan.gc.ca/equipment

FIGURE 4-11

EnerGuide Label for Appliances

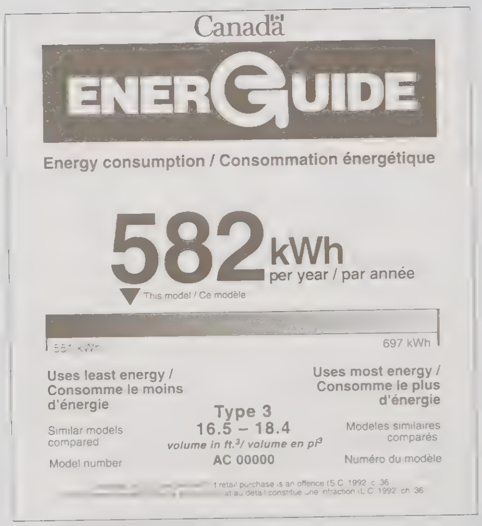


FIGURE 4-12

EnerGuide Label for Air Conditioners

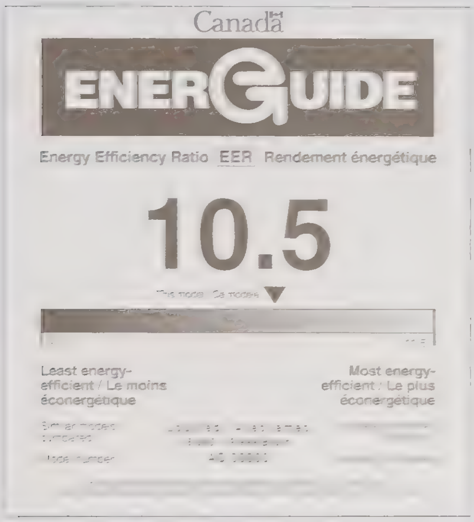


FIGURE 4-14

Unit Energy Consumption for Top-Mounted Auto-Defrost Refrigerators Marketed in Canada, 1991 and 2001 Models

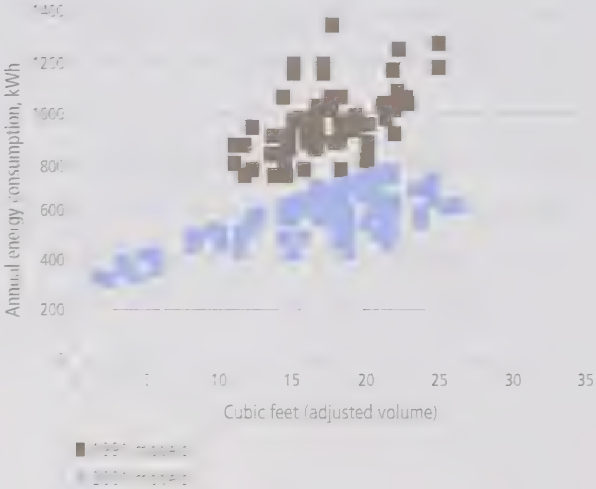


FIGURE 4-13

Average Energy Consumption of New Appliances, 1990 and 2000 Models

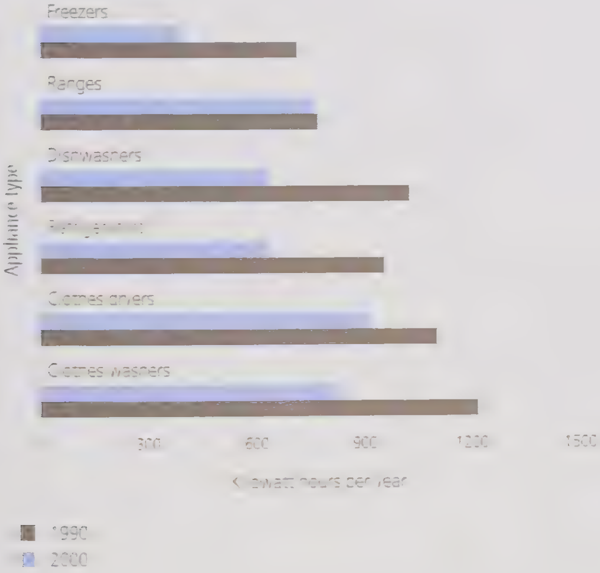
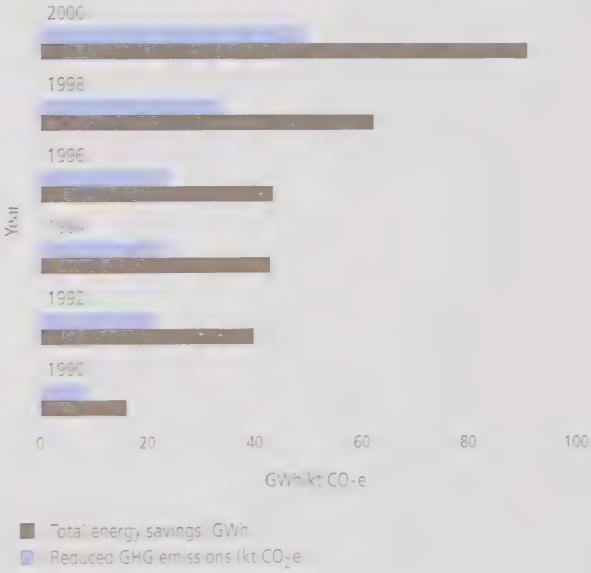


FIGURE 4-15

Total Energy Savings and GHG Emissions Reductions Attributable to the EnerGuide for Equipment Program, 1990 to 2000



Chapter 5: Buildings

Energy Use and Greenhouse Gas Emissions

The commercial and institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services, including tourism. This sector uses energy mainly for space and water heating, space cooling, lighting, motive power for services such as pumping and ventilation in buildings, and street lighting.

In 2000, the commercial and institutional sector accounted for 13.0 percent (1059 petajoules) of secondary energy use and 12.6 percent (59.9 megatonnes) of greenhouse gas (GHG) emissions.

This sector comprises many building types (see Figure 5-1). Retail and office space account for nearly half of commercial and institutional sector energy demand. Schools, health care facilities and hotels and restaurants account for another 35 percent of that demand. NRCan programs address all of these major energy-using building types.

Energy is used for six purposes in commercial and institutional buildings. The largest of these is space heating, which accounts for more than half of this sector's entire energy demand (see Figure 5-2). Each of the remaining five uses of energy in this sector accounts for between 4.0 and 14.0 percent of its energy demand.

Between 1990 and 2000, commercial and institutional energy use increased by 22.1 percent, or 192 petajoules (from 867 to 1059 petajoules). However, GHG emissions from the sector rose by 25.3 percent in the same period. The main factor causing emissions to increase more quickly than energy use was the increased use of energy sources with a higher GHG content.

FIGURE 5-1

Commercial and Institutional Energy Use by Building Type, 2000

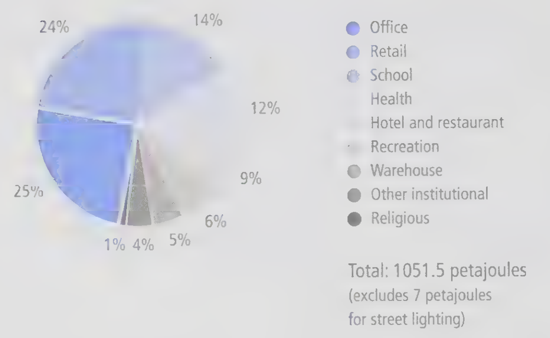


FIGURE 5-2

Commercial and Institutional Energy Use by Purpose, 2000

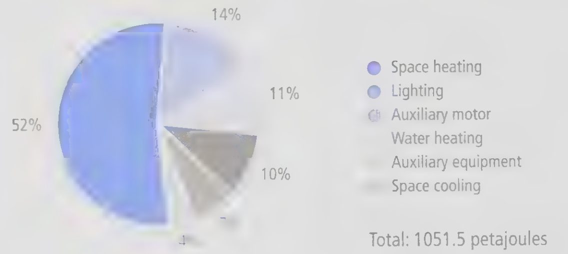


FIGURE 5-3

Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000

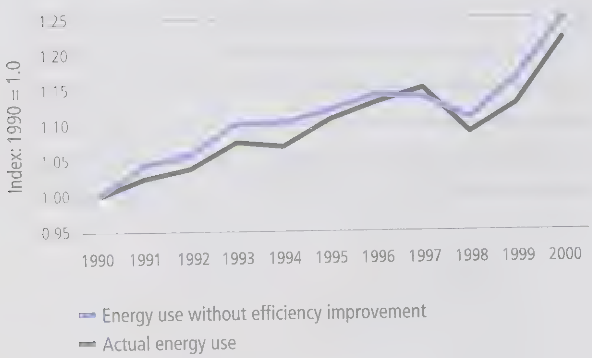
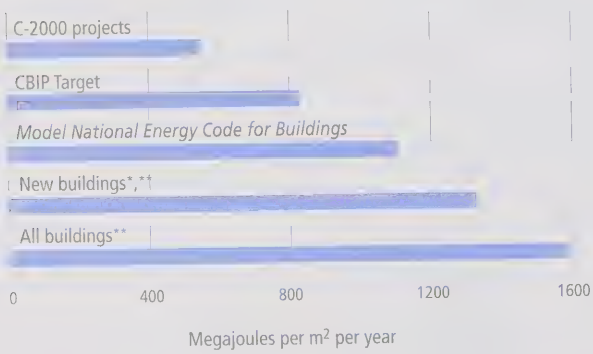


FIGURE 5-4

Energy Use in Commercial Buildings, 1999



* 1990–1999
** Source: Commercial and Institutional Building Energy Use Survey, 2000. Estimates relate only to the surveyed area of populations over 175 000 and in Atlantic Canada populations of over 50 000.

FIGURE 5-5

Market Penetration of Energy Innovators Initiative in Commercial and Institutional Sectors

During the period 1990–2000, activity was the main factor tending to increase energy use; energy efficiency tended to decrease energy use. Structure (the mix of building types) and weather varied by only a minor extent. Specifically, the changes attributed to each of these factors are

- activity – an increase of 205 petajoules in energy use;
- weather – an increase of 8 petajoules;
- energy efficiency – a decrease of 22 petajoules; and
- structure – an increase of 3 petajoules.

If only activity, weather and structure had been in effect, commercial and institutional energy use would have increased by 25.0 percent (217 petajoules). However, improvements in energy efficiency worked to decrease energy use by 2.7 percent (23 petajoules). As a result, energy use increased by only 22.1 percent. This change in energy use during 1990 to 2000, as well as the energy savings due to energy efficiency, is shown in Figure 5-3.

NRCan delivers initiatives to increase energy efficiency in the following subsectors of the commercial and institutional sector:

- new buildings;
- existing buildings; and
- equipment.

New Buildings: Commercial Building Incentive Program (CBIP)

Objective: To improve the energy efficiency of new commercial, institutional and multi-unit residential buildings.

CBIP provides financial incentives to builders and developers who incorporate energy-efficient features into the design and construction of new commercial, institutional and multi-unit residential buildings (MURBs). To qualify for the incentive, buildings must be at least 25 percent more efficient than similar buildings constructed to the *Model National Energy Code for Buildings* (MNECB).

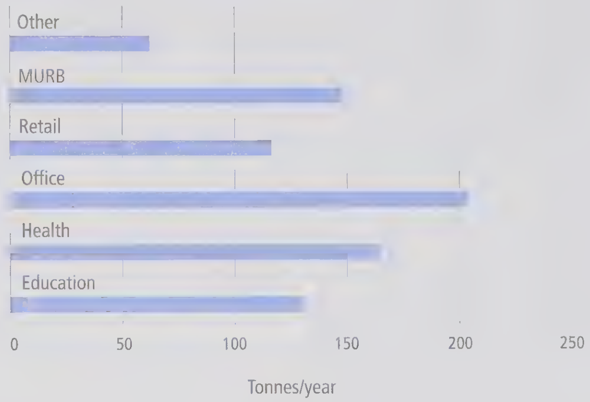
Key 2001–2002 Achievements

- 63 new contributions worth over $4.2 million in total were issued to building owners.
- 700 engineers and architects were exposed to CBIP via the Royal Architectural Institute of Canada's continuing education.

For more information:
oee.nrcan.gc.ca/newbuildings/cbip.cfm

FIGURE 5-6

Average GHG Reductions by Institution Under CBIP, 2002



New Buildings: Industrial Building Incentive Program (IBIP)

Objective: To improve the energy efficiency of new industrial buildings.

IBIP extends the precepts of CBIP to the industrial sector. IBIP offers an incentive to companies building new energy-efficient industrial facilities, to offset additional design costs inherent in the initial attempts at energy-efficient designs and building/process integration. The design is assessed against a reference generated from the MNECB.

Key 2001–2002 Achievements

- Signed two contribution agreements.

For more information:
oee.nrcan.gc.ca/newbuildings/ibip.cfm

New Buildings: Green Buildings

Objective: To reduce energy and resource consumption and dangerous emissions from commercial buildings while increasing cost effectiveness through the use of high-performance buildings.

The program plays a significant role in establishing goals for energy efficiency and sustainability in commercial buildings through various activities, including C-2000, the Green Building Challenge (GBC) and integrated design process charrettes. NRCan launched the GBC process in 1996 to develop an international method of assessing the environmental performance of buildings and to test it on buildings in each country. GBC staff provide technical advice and support to NRCan's CBIP.

- For CBIP, staff analysed 1200 Expressions of Interest and more than 700 building submissions. Of these, 214 have shown energy-use improvements of at least 25 percent compared with the MNECB reference. On average, CBIP buildings were 32 percent better than the level required by the MNECB, at an average cost premium of 4.5 percent. Four of those buildings showed reductions of between 40 and 45 percent for no capital construction cost increase.
- GBC process assessments are conducted with GBTool™, developed by NRCan. At the first GBC conference, 14 countries participated; at the second in 2000, 19 countries. The third event, held in Oslo, Norway, in September 2002, showed the work of 16 participating national teams. Since 1996, 26 different countries have been involved.

Key 2001–2002 Achievements

- The first building in Manitoba completed under NRCan's C-2000 Program for Advanced Commercial Buildings opened. The Mountain Equipment Co-op store represents one of the most aggressive attempts in North America to reduce embodied energy in new construction, with 95 percent of the building constructed out of recycled and reused materials.
- Helped organize an energy-efficient design charrette for a large renovation project in Montréal, Quebec. This workshop, intended to develop design ideas for major projects, is expected to have a major influence on the Montréal design community.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Existing Buildings: Energy Innovators Initiative

Objective: To encourage commercial businesses and public institutions to make investments in energy efficiency and reduce GHG emissions.

The Energy Innovators Initiative (EII) helps commercial organizations and public institutions explore energy efficiency options and strategies, offering them access to tools and financial assistance to help reduce energy costs and improve competitiveness. Members join EII by sending a letter to the Minister of Natural Resources Canada that makes a commitment to energy efficiency.

Key 2001–2002 Achievements

- By the end of the fiscal year, over 700 organizations representing about 30 percent of the sector's floor space had been recruited as Energy Innovators.

TABLE 5-1

Energy Innovators Initiative, Incentive Projects from 1998 to 2002

Federal incentive	$12.8 million
Client investment	$259.7 million
Annual energy savings ($)	$32 million
Annual energy savings (gigajoules)	2.398 million

For more information:
oee.nrcan.gc.ca/eii/home.cfm

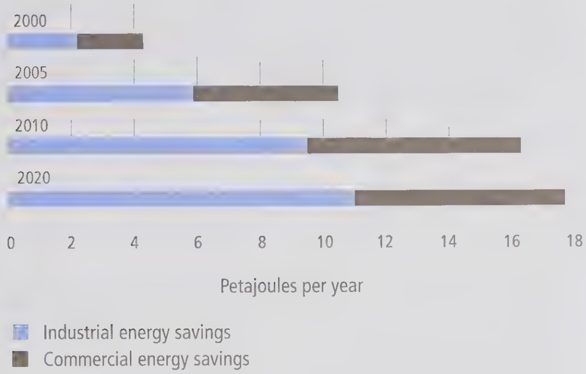
Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy-performance levels and labelling requirements.

FIGURE 5-7

Estimated Energy Savings from Motor Regulations, 2000 to 2020



Key 2001–2002 Achievements

- The Regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial and institutional sector.

For more information:
oee.nrcan.gc.ca/regulations/home_page.cfm

TABLE 5-2

Savings Arising from Canadian Energy Efficiency Lighting Regulations

Annual sales of lamps affected by regulations	$33 million
Estimated direct savings of electricity used for lighting in 2000	39 petajoules
Estimated net energy savings in 2000*	10 petajoules
Estimated net reduction in GHG emissions in 2000	5.5 megatonnes

*The estimate of net energy savings is lower than the estimate of direct savings of electricity and is partially offset by an increase in space-heating demand required because more efficient lighting emits less heat. When this effect is taken into account, estimated energy savings are less. The net effect varies by region and building.

Equipment: Buildings Program

Objective: To develop and transfer refrigeration and intelligent buildings technologies, in partnership with industry, and provide technical support for the deployment of ground-source heat pumps.

Key 2001–2002 Achievements

- With partners in Quebec, retrofitted an arena in Victoriaville and installed energy-saving equipment at a new arena in Val-des-Monts. These projects demonstrate energy-efficient technologies and practices.
- Completed prefeasibility study of advanced refrigeration, heating, cooling and dehumidification technologies for a "green supermarket" in Quebec.
- Began testing the Diagnostic Agent for Building Operators, a computerized tool that allows the detection and diagnosis of mechanical system defects in buildings.
- Initiated project to develop an intelligent building controller with fault detection and diagnosis for commercial buildings.

For more information:
cetc-varennes.nrcan.gc.ca/eng/batiments.html

Equipment: Simulation

Objective: To contribute to the improvement of performance, cost-effectiveness and integration and deployment of energy-efficient building technologies and techniques, including applications-driven implementation tools for market.

Through the Simulation Program, the Simulation Team develops, distributes and supports building simulation software for the Canadian building industry. Architects and engineers use these software tools to optimize the energy performance of building designs and to demonstrate compliance with programs and regulations such as R-2000, CBIP, the *Model National Energy Code for Buildings* and the *Model National Energy Code for Houses*. The team is involved in all aspects of the software development process, from design and programming to distribution, maintenance, user training and user support.

- Over 44 874 houses have been simulated for NRCan's R-2000 Initiative and EnerGuide for Houses program; 799 simulations have been performed to meet CBIP requirements.
- NRCan designed the world's first whole-building simulation model with solid oxide fuel cell cogeneration capabilities, incorporated it into a custom software package and delivered it to a Canadian fuel cell manufacturer to help it optimize its technology design.

Key 2001–2002 Achievements

- Hosted the first Canadian conference on building energy simulations (eSim), leading to the formation of a Canadian chapter of the International Building Performance Simulation Association and a commitment by the association to hold an annual eSim conference.
- Established residential-building energy simulation network with six universities (Concordia, Dalhousie, École Polytechnique de Montréal, Ryerson, Toronto, Waterloo). Through the network, new-building simulation research, algorithm development and simulation techniques are being developed, which will advance Canadian capacity for building simulation.

For more information:
buildingsgroup.nrcan.gc.ca/simulation/simulation_e.html

Equipment: Bringing Energy-Efficient Technologies to Market

Objective: To accelerate the development and adoption of energy-efficient building technologies into market.

The program works in partnership with associations, government and business to develop highly specialized solutions, thereby helping to reduce the energy consumption and GHG emissions of buildings in Canada in a cost-effective manner.

- Activities in energy-efficient ventilation for improved air quality have resulted in the commercialization of the residential heat recovery ventilator. Canadian companies now turn out up to 50 000 units a year. In cooperation with the Heating, Refrigeration and Air Conditioning Institute of Canada, NRCan has supported the development of national standards for residential mechanical ventilation, as well as training and education programs for equipment installation.
- In cooperation with the Canadian window industry, program staff developed CSA International standards, guidelines and tools to enable energy-efficient windows to be commercialized. Staff were involved in developing the Edgetech Super Spacer® for windows, which was made available to the market in the early 1990s.

Key 2001–2002 Achievements

- Unveiled the new ēKOCOMFORT™ system, a product that integrates a space-heating system, water heating and ventilation. Six companies were selected to contribute to developing such advanced home-energy systems. The first of the products has now entered the market.
- The Canadian Centre for Housing Technology is an advanced testing facility for housing technologies managed in partnership between NRCan, National Research Council Canada and Canada Mortgage and Housing Corporation. Products tested this year include advanced integrated mechanical systems, a waste-water heat recovery system and electronically commutated motors.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Chapter 6: Industry

Energy Use and Greenhouse Gas Emissions

The industrial sector includes forestry, construction and mining as well as all manufacturing. This sector uses energy in industrial processes as a source of motive power, to produce heat or to generate steam. Overall, industrial energy demand accounts for 39.2 percent (3069 petajoules) of secondary energy use and 33.6 percent (151 megatonnes) of greenhouse gas (GHG) emissions.

Within the industrial sector, energy is consumed primarily in the petroleum refining, iron and steel, upstream mining, aluminum, organic chemicals, pulp and newsprint and other paper industries. Together, these sectors accounted for 64.5 percent of total industrial energy demand in 2000 (see Figure 6-1).

In most industries, energy purchases account for only a small proportion of total expenditures. However, for some relatively energy-intensive industries – lime, cement, magnesium and aluminum – this share is higher than 15.0 percent (see Figure 6-2).

After decreasing slightly from 1990 to 1991 as a result of the recession, industrial energy use had increased by about 16.3 percent (449 petajoules) by 2000 (from 2755 to 3204 petajoules) (see Figure 6-3). The main factor that increases industrial energy use is activity:

- activity – increases in physical industrial output, gross output and gross domestic product contributed to an increase in energy use of 36.5 percent (1005 petajoules); and
- structure – the change in the mix of activity toward less energy-intensive industries (such as electric and electronic) resulted in an 11.5 percent decrease in energy use (317 petajoules).

FIGURE 6-1

Industrial Energy Use by Subsector, 2000

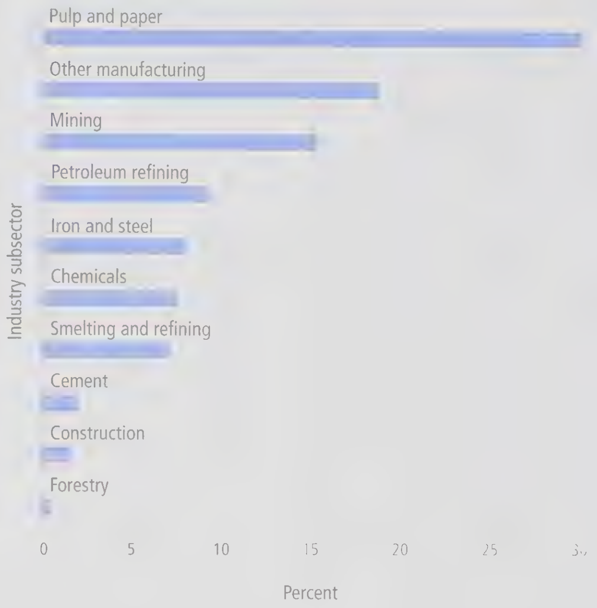


FIGURE 6-2

Cost of Energy to Industry as a Percentage of Total Production Cost, 1998

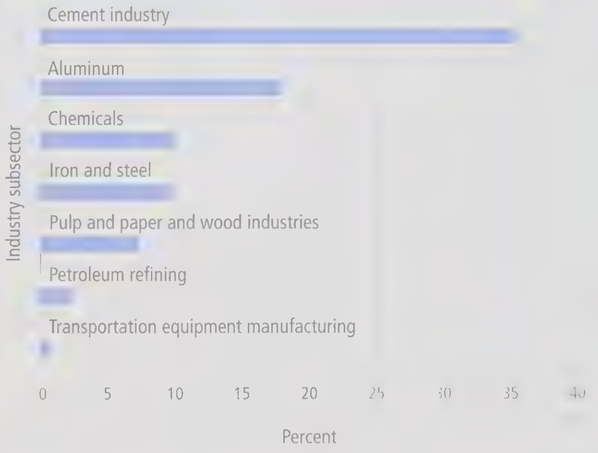


FIGURE 6-3

Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000

FIGURE 6-4

Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 2000

If only these two factors had been in effect, industrial energy use would have increased by 25.0 percent (688 petajoules). However, improvements in energy efficiency worked to decrease energy use by 8.7 percent (239 petajoules). As a result, energy use increased by only 16.3 percent. This change in energy use during 1990 to 2000 and the energy savings due to energy efficiency are shown in Figure 6-3.

Whereas energy use between 1990 and 2000 increased by 16.3 percent, industrial GHG emissions increased by only 12.9 percent.

Natural Resources Canada (NRCan) delivers initiatives to increase energy efficiency in the following subsectors of the industrial sector:

- industrial processes and technologies; and
- equipment.

Industrial Processes and Technologies: Industrial Energy Efficiency

(Canadian Industry Program for Energy Conservation [CIPEC] and Industrial Energy Innovators [IEI])

Objective: To help Canadian industry use energy efficiency investments to improve competitiveness and to contribute to Canada's climate change goals.

CIPEC, a sector-level program, and IEI, a company-level program, address barriers to planning, implementing and tracking energy efficiency projects in industry. Key elements include the establishment and tracking of energy efficiency improvement targets and plans, and the development of products that overcome barriers to continued energy efficiency improvement. NRCan provides support via employee awareness kits, best-practices guides, technical information and workshops on energy management.

Key 2001–2002 Achievements

- Signed Letters of Cooperation were received from the Canadian Association of Petroleum Producers, the Small Explorers and Producers Association of Canada, the Canadian Electricity Association, the Canadian Construction Association and the Fisheries Council of Canada.
- Launched energy management workshops in the upstream oil and gas sector.

For more information:
oee.nrcan.gc.ca/cipec/ieep

FIGURE 6-5

Industrial Energy Innovators and Action Plans, 1995–1996 to 2001–2002

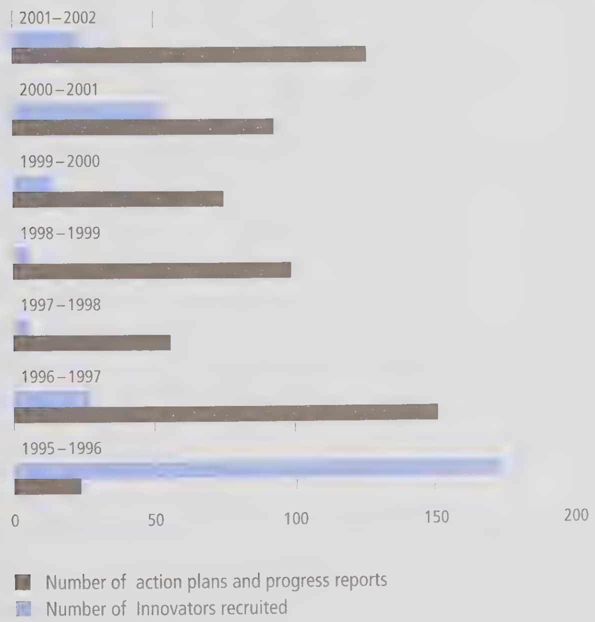
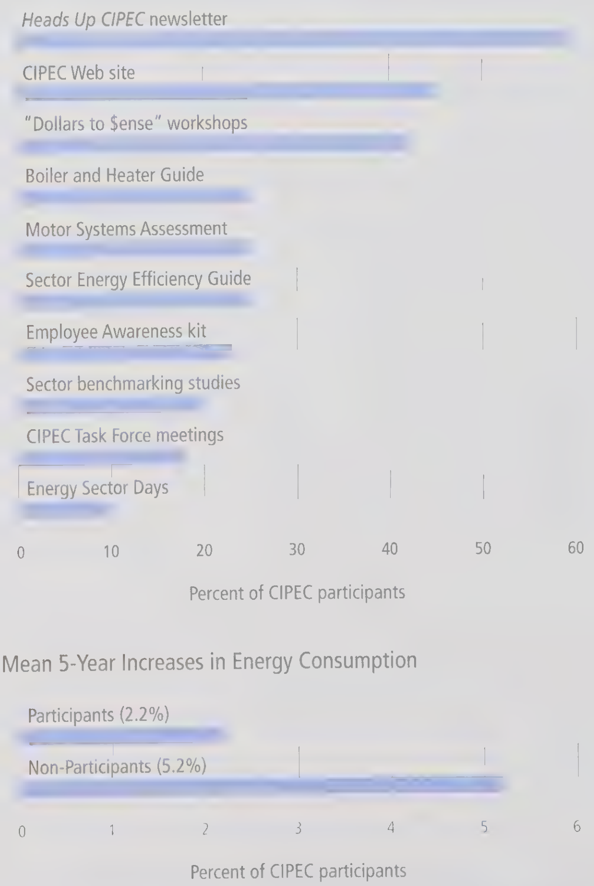


FIGURE 6-6

Participation in CIPEC Program – Participation Level in Program Elements and Consequences to Energy Consumption



Industrial Processes and Technologies: Advanced Combustion Technologies

Objective: To help industry develop cleaner, more energy-efficient combustion processes, with lower emissions of acid rain precursors, GHGs, particulates and identified priority substances – trace elements and organic compounds.

Research focuses on optimizing the performance of stationary combustion equipment and developing and evaluating new products, fuels and retrofit technologies, using conventional fuels – oil, coal and natural gas – as well as biomass and specialty fuels.

Key 2001–2002 Achievements

- Completed a series of tests, burning mixtures of coal and tar-pond sludge in a mini-circulating fluidized bed combustion facility, demonstrating the technology to be an environmentally benign way of destroying PCB-laden tarry sludge from the tar ponds in Sydney, Nova Scotia.
- Successfully completed a six-year testing program for Syncrude Canada Ltd. that will enable Syncrude to significantly increase the yield from its cokers by optimizing operating parameters and nozzle design.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_act_e.html

Industrial Processes and Technologies: Processing and Environmental Catalysis Program

Objective: To solve industrial process problems and undertake research in areas with high potential for significant environmental and economic benefits.

The program's facilities, including semi-pilot scale plants, are used for process testing and the evaluation of novel concepts in chemical and energy conversion. Clients include oil and gas companies, petrochemical companies, original engine manufacturers, waste oil renderers and specialty ceramic manufacturers.

Key 2001–2002 Achievements

- Obtained two patents on novel materials for proton-conducting ceramic membrane materials for hydrogen separation and made significant improvement to ceramic membranes for hydrogen separation.
- Proved the concept of a new generation of fuel cell reactor technology, offering significant improvement in energy efficiency for the chemical processing of natural gas to synthesis gas or hydrogen.
- Developed technology for the production of low-sulphur, high-cetane blending stock from waste restaurant grease and vegetable oils. Engine testing of fuels blended with this oil is underway.
- Filed patent on a low-temperature technology for removing sulphur from waste oil products. This improved energy-efficient process is now being tested.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_pec_e.html

Industrial Processes and Technologies: Industrial Process Engineering Program

Objective: To enable industry to continuously improve its energy efficiency and productivity, while decreasing GHG and other pollutant emissions.

The program focuses on industrial drying and the catalytic flow reversal reactor technology. It seeks to meet its objective by performing leveraged research and development (R&D), introducing novel technologies, performing incremental improvements, performing industrial audits and disseminating technical information.

Key 2001–2002 Achievements

- Signed licence agreement with a multinational dryer company to market the NRCan-developed-and-patented, energy-efficient, pulse fluid bed dryer in Canada and around the world.
- Initiated five-year project to reduce energy consumption in the solid-wood manufacturing sector. The project will reduce the energy consumption of wood kilns by an average of 15 percent, which could translate into a reduction of 500 kilotonnes of carbon dioxide (CO_2) emissions per year.
- In collaboration with partners, began joint project to develop a new control method to improve efficiency in wood-drying sawmill operations.
- Signed contract with Manitoba Hydro to adapt jet-spouted bed-drying technology for processing food and agri-food products. This energy-efficient technology improves the quality of the dried products in food processing plants.

For more information:
cetc-varennes.nrcan.gc.ca/eng/industrie.html

Industrial Processes and Technologies: Industrial Process Integration Program

Objective: To support the development and adoption of process integration in various industries.

The program focuses on combined-heat-and-power optimization methodologies; total site optimization methodologies; batch-processes optimization methodologies; and water-pinch optimization methodologies in the agri-food, pulp and paper and textile industries. It also focuses on building an international-calibre Canadian capacity in process integration.

Key 2001–2002 Achievements

- Two-day course on optimization of industrial cogeneration and site utility systems management for industry, utility providers and government representatives.
- With Anjou-Recherche (Vivendi Water Inc.), produced a study of a metallurgical plant to optimize its cooling system. The study used state-of-the-art distributed-cooling methodologies and optimization techniques developed by NRCan.
- Began a process integration study at the Norampac Inc. paperboard mill in Red Rock, Ontario, to identify and evaluate energy savings and water management opportunities.
- With Quebec's Agence de l'efficacité énergétique, completed analysis and review of energy-efficient best practices in the meat and dairy processing sectors and the beer and beverage industries.

For more information:
cetc-varennes.nrcan.gc.ca/eng/programmes_industrie.html

Industrial Processes and Technologies: Industry Energy Research and Development (IERD) Program

Objective: To encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, products, systems and equipment in industry.

Financial support is provided for commercially confidential applied R&D activities, which is repayable if the project is commercially successful. Program clients from all industrial sectors range from small- and medium-sized companies to multinational corporations.

- Since its inception (1977), IERD has helped a variety of Canadian companies, supporting 125 R&D projects and contributing $93 million toward $388 million-worth of projects for the development of advanced energy-efficient technologies. This effort also contributes inherently to sustainable development and GHG emissions reduction.

Key 2001–2002 Achievements

- Diversified Metals Engineering of Prince Edward Island is developing systems to recover and use waste heat from marine diesel engines. The system reduces fuel consumption and removes sulphur dioxide and particulate matter.
- Turbocor Inc. of Quebec is developing a new non-chlorofluorocarbon compressor for refrigeration application. This equipment represents a break-through in industrial and commercial refrigeration and is expected to yield energy savings of 30 percent.
- Ontario's Fielding Chemical Technologies Inc. is developing a process to recycle industrial solvent and waste streams. Sizeable energy savings and related GHG emissions reductions could be achieved by reusing these solvents.
- Agile Systems Inc. of Ontario is developing an electronics control technology that will accelerate the market uptake for fuel cells in residential and automotive applications by offering increased flexibility and reduced space, weight and cost.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_ierd_e.html

Industrial Processes and Technologies: Emerging Technologies Program (ETP)

Objective: To support the identification and demonstration of new and emerging energy-efficient technologies.

Projects are co-managed and cost-shared with industry and other stakeholders, such as gas and electric utilities, other governments and equipment manufacturers. Most activities have taken place within the industrial sector. Financial support is provided for the development and testing of pilot plants, prototypes and full-scale field trials to evaluate operating performance, energy efficiency and environmental impacts. NRCan's financial support is repayable from any cost savings or revenues realized from a project.

- Since 1991, ETP and its forerunner, the Industrial Targeted Program (ITP), have contributed $19 million to 105 projects worth $143 million.

Key 2001–2002 Achievements

- ZENON Environmental Inc. demonstrated its water filtration technology in a range of applications. The technology uses 80 percent less energy than conventional methods.

- Participated with a number of leading Canadian coal users in study, development and demonstration of clean coal technology for power generation.
- Westport Research Inc. undertook a one-year field trial of a low-emissions natural gas engine for stationary power generation.
- Hydrogenics Corporation is developing an automated test station for residential fuel cells and their sub-systems.
- Levelton Engineering Ltd. tested high-volume fly ash in roller compacted concrete in an industrial paving application. By replacing cement with fly ash, the energy content and CO_2 emissions from concrete production are reduced significantly.

Industrial Processes and Technologies: Energy Technologies for High-Temperature Processes (EHTP)

Objective: To investigate technologies and develop knowledge to ensure the sustainability of Canada's coal, carbon and metallurgical industries.

EHTP has expertise in carbonization, combustion, agglomeration, thermal rheology petrography and environmental and carbon science technologies to address energy efficiency, GHG reduction and related needs of industry. Key areas include alternative iron-making technology, fuel products, iron and steel process efficiency, standardization and analysis of emissions.

Key 2001–2002 Achievements

- Completed coke stabilization study for two Canadian steel plants, demonstrating significant opportunities to improve coke quality, reduce coke consumption and achieve significant energy savings. As a result, one Canadian steel company has set targets for improved coke quality to achieve voluntary GHG reduction limits.
- Published reports on coke modelling, showing that Canadian coal can be substituted for Australian coal in Steel Authority of India blends. This could open India's $300-million coking coal market to Canadian coals.
- Coal and natural gas co-injection studies for Stelco Inc. and Union Gas Limited highlighting improved energy efficiencies in iron-making.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_ehtp_e.html

Industrial Processes and Technologies: International Centre for Sustainable Development of Cement and Concrete (ICON)

Objective: To support the growth of concrete as a valuable building material, a sustainable development approach is needed toward the production of cement and concrete, an approach that balances environmental concerns with social and economic considerations.

ICON continues to work with the cement and concrete industry to develop and evaluate high-performance concretes, to increase their durability and mitigate the effects of alkali aggregate reaction and to promote the use of supplementary cementing materials, particularly high-volume fly ash concrete, in order to help reduce global demands for Portland cement.

Key 2001–2002 Achievements

- Sponsored, organized and conducted 7th CANMET/ACI International Conference on Fly Ash, Silica Fume, Slag and Natural Pozzolans in Concrete, Madras, India, July 2001.
- Sponsored, organized and conducted 5th CANMET/ACI International Conference on Recent Advances in Concrete Technology, Singapore, August 2001.
- Successful completion of a design mission for a development project in India sponsored by the Canadian International Development Agency. It included identification of key Indian stakeholders and partners, evaluation of Indian fly ash for use in the High-Volume Fly Ash Concrete System developed at CANMET and a successful field trial in the state of Maharashtra.
- Contributed to the development of a new air-entraining admixture for use in concrete, incorporating fly ash with high-carbon content. Project in collaboration with the industry and Université de Sherbrooke.

Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy performance levels and labelling requirements.

Key 2001–2002 Achievements

- The Regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial and institutional sector.

For more information:
oee.nrcan.gc.ca/regulations

Equipment: EnerGuide for Industry

Objective: To promote and encourage the manufacture, purchase and use of more energy-efficient industrial equipment.

EnerGuide for Industry is a labelling/rating program for industry that follows principles similar to those for the EnerGuide for Equipment program. EnerGuide for Industry targets commonly used "off the shelf" industrial equipment, such as motors, pumps, transformers, compressors, boilers and lights. The program aims to ultimately reduce energy-use-related GHGs by improving the efficiency of the stock of energy-using equipment available for industrial applications.

Key 2001–2002 Achievements

- High-Intensity Discharge Ballast study completed.

Equipment: Mine Ventilation

Objective: To reduce energy consumption associated with mine ventilation by using the concept of "ventilation on demand," ventilation infrastructure automation and ventilation network optimization and management.

Electrical energy associated with mine ventilation represents about 40 percent of the electrical energy required for underground mine production. Furthermore, there is a cubic relation between a given airflow reduction and the power economy that ensues, making ventilation management a worthwhile endeavour, both economically and environmentally.

Key 2001–2002 Achievements

- Feasibility study of using "ventilation on demand" within INCO Limited's Creighton Mine's deep ore zone to minimize ventilation costs.
- NRCan scientist has begun Ph.D. studies at the University of British Columbia in collaboration with INCO Limited. The thesis deals with linking mine-ventilation delivery and modelling with computerized mine-development models to reduce ventilation costs.

Equipment: Water-Powered Hydraulic Drill (CANDRILL)

Objective: To reduce hazards faced by miners, while increasing energy efficiency.

The CANDRILL, a rockdrill powered by a high-pressure water system rather than compressed air, and the system that runs it, will dramatically reduce several of the hazards faced by miners while at the same time increasing efficiency. At present, compressed air is the main power source for narrow-vein mining equipment. Rockdrills powered by compressed air create high levels of noise, dust and vibration while generating an oil mist that is a potential health hazard. These factors cost the mining industry many thousands of dollars every year in Canada alone. The CANDRILL will increase energy efficiency (from 30 to 50 percent) while dramatically reducing several of the hazards faced by miners.

Key 2001–2002 Achievements

- Testing indicates that, compared with its compressed-air counterpart, the new rockdrill drills holes twice as quickly, offers reduced vibration, dust and noise (15 decibels quieter), weighs less (14 kilograms lighter) and eliminates oil mist emissions.

Chapter 7: Transportation

Energy Use and Greenhouse Gas Emissions

The transportation sector consists of three subsectors: passenger, freight and off-road. Passenger and freight transportation accounted for 56.7 percent and 39.7 percent, respectively, of transportation energy use, with off-road representing only 3.6 percent in 2000. The passenger subsector is composed of three modes: road, rail and air. The freight subsector comprises road, rail and marine. Road transport uses the most energy, accounting for 77.3 percent of total transportation energy use in 2000. Of this amount, 59.7 percent was passenger energy use and 40.3 percent was freight energy use (see Figure 7-1). All NRCan transportation energy-use programs focus on the energy used in road transportation.

Transportation energy use increased by more than 21.5 percent (404 petajoules) during the years 1990 to 2000 (see Figure 7-2). Passenger transportation energy use increased by almost 12.6 percent (145 petajoules), while freight transportation energy use increased by 34.1 percent (230 petajoules). Two main factors were responsible for this increase – activity and structure:

- activity – due to increases in population and economic activity, there was greater transportation activity (measured as passenger-kilometres for passenger transportation and tonne-kilometres for freight transportation). This increased transportation energy use by almost 23 percent (410 petajoules). The freight and passenger segments contributed to this increase by 60.4 percent and 39.6 percent, respectively; and
- structure – shifts between modes of transport were significant in the freight segment, resulting in an increase of more than 8.9 percent in transportation energy use (177 petajoules).

FIGURE 7-1

Transportation Energy Use by Mode, 2000

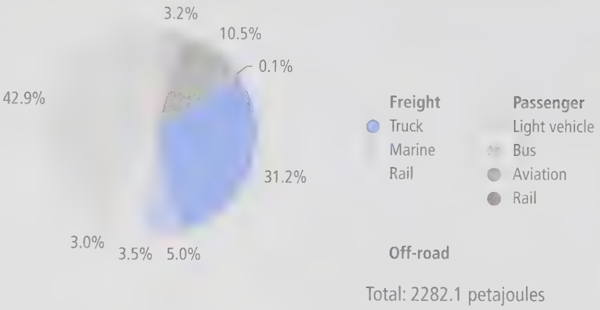


FIGURE 7-2

Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000

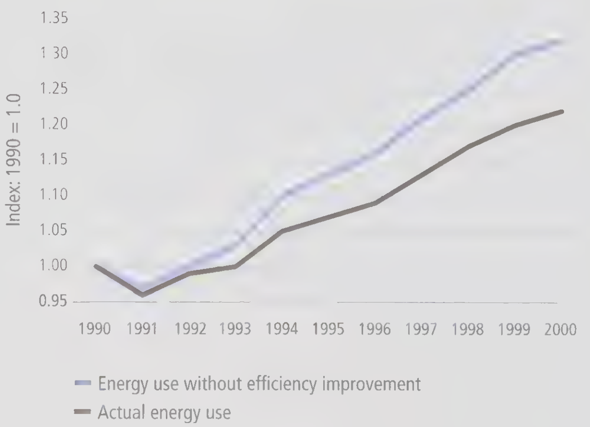


FIGURE 7-3

Market Shares of New Light Trucks and Passenger Cars, 1990 to 2000

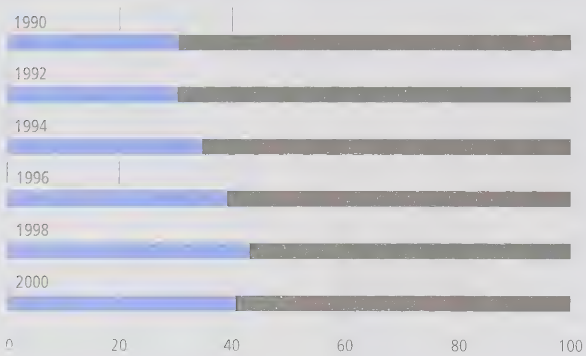
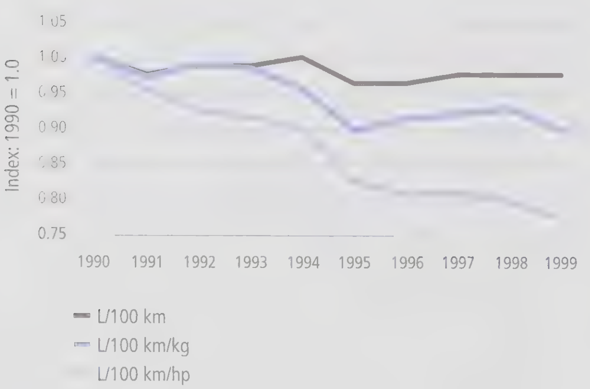


FIGURE 7-4

New Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 1999



If only these two factors had been in effect, transportation energy use would have increased by almost 39.9 percent (588 petajoules). However, improvements in energy efficiency worked to decrease energy use by 11.3 percent (202 petajoules). As a result, energy use increased by only 21.5 percent. This change in energy use during 1990 to 2000, as well as the energy savings due to energy efficiency, is shown in Figure 7-2.

The transportation sector accounts for more than 28 percent (2282 petajoules) of secondary energy use and more than 34.5 percent (163 megatonnes) of greenhouse gas (GHG) emissions. From 1990 to 2000, transportation energy use increased by more than 21.5 percent, and GHG emissions increased by 21.0 percent. The change in GHG intensity of transportation energy use was negligible.

NRCan delivers initiatives in the following areas to increase the efficiency of motor vehicles and encourage the use of alternative fuels:

- personal vehicles;
- commercial fleets;
- transportation research and development; and
- alternative transportation fuels.

Personal Vehicles: Vehicle Efficiency Targets

Objective: To improve the fuel efficiency of new motor vehicles.

This initiative with vehicle manufacturers aims to improve motor vehicle fuel efficiency. The initiative encourages manufacturers to voluntarily meet standards for company average fuel consumption for new automobiles and light trucks sold in Canada. In addition, Natural Resources Canada (NRCan) and vehicle manufacturers seek to improve both new vehicle and on-road vehicle fuel efficiency through advancements in vehicle technology and changes in the behaviour of vehicle owners and operators.

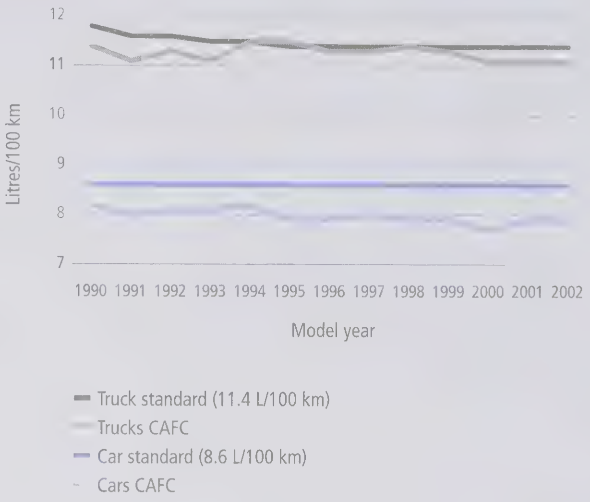
Key 2001–2002 Achievements

- Policy coordination and joint studies under the NRCan/U.S. Department of Energy Memorandum of Understanding to support the development of a new fuel efficiency target.
- Reports: *Analysis of Alternative Fuel Economy Program Designs*; *Assessment of costs and fuel economy potential of 42-volt hybrid drive technologies*.
- Consultations with stakeholders and partners on implementing the consumer education campaign.
- Market research in partnership with the Canadian Petroleum Products Institute, the Agence de l'efficacité énergétique du Québec and Transport Canada.
- Thirty advanced technology vehicles acquired, 352 evaluations completed.

For more information:
oee.nrcan.gc.ca/english/programs/motorvehicles.cfm

FIGURE 7-5

Company Average Fuel Consumption (CAFC) vs. Canadian Voluntary Standards

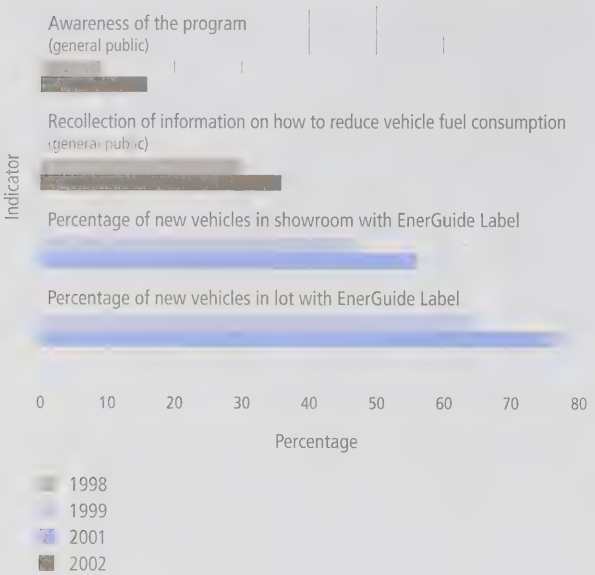


Personal Vehicles: Personal Vehicle Program

Objective: To improve motor vehicle fuel efficiency by encouraging private motorists to develop energy-efficient vehicle purchase, use and maintenance practices.

FIGURE 7-6

Vehicle Fuel Efficiency Awareness



Under a voluntary agreement, vehicle manufacturers attach an EnerGuide fuel consumption label to new cars, vans and light-duty trucks to be sold in Canada. This and the annual *Fuel Consumption Guide* provide consumers with fuel consumption ratings and the estimated annual fuel cost of the vehicle. Additionally, the annual EnerGuide for Vehicles Awards highlight the year's most fuel-efficient vehicles in each size class.

The program encourages motorists to buy, drive and maintain their vehicles in energy-efficient ways that save fuel and money, and reduce vehicle emissions through various kits, guides, information dissemination activities and strategic alliances with public and private sector organizations. In addition to a guide, Web site and education and awareness campaigns, resource materials on vehicle fuel efficiency are provided to driver educators for their novice-driver training curricula.

Key 2001–2002 Achievements

- Recruited Volvo Cars of Canada Ltd. to the EnerGuide for Vehicles program and retained all other companies.
- Achieved 77 percent compliance for EnerGuide for Vehicles on dealership lots, 56 percent in showrooms.
- Distributed over 285 000 copies of the 2002 *Fuel Consumption Guide* through vehicle dealerships, distributed 700 000 publications and logged over 145 000 user sessions on the Web site.
- Reached over 170 000 novice drivers directly; exhibited the student driving materials at three workshops (each averaging 600 participants) and at one annual conference (50 participants).

For more information:
oee.nrcan.gc.ca/vehicles

Commercial Fleets: Fleet Vehicle Program

Objective: To improve fuel efficiency and the use of alternative fuels in commercial and municipal fleets.

Information materials, workshops, technical demonstrations and training programs help fleet operators assess and develop opportunities to increase energy efficiency in their operations. NRCan delivers the program in partnership with fleet and industry associations and other levels of government.

Key 2001–2002 Achievements

- Total of 2707 registered members, representing 386 731 vehicles. Fiscal year saw 2180 new trainers and about 125 000 drivers, experienced and entry-level, in heavy truck and forest sectors, given SmartDriver materials. Launch of SmartDriver for Forestry Trucks program.
- Piloted "Fuel Management 101" workshop; provides fleet owners and managers with tools to develop and implement an energy management plan.
- Agreement with Canadian Association of Motive Power Educators (CAMPE) to deliver the "Fuel Management 101" workshop and develop a data-collection strategy to help fleets determine their fuel efficiency and GHG emissions baseline. This initiative will provide engine technician students with on-the-job supervised work experience and give the program an excellent source of fuel consumption and vehicle use data.
- Agreement with the Canadian Electricity Association to investigate the feasibility and viability of truck-stop electrification in the Canadian context.

For more information:
oee.nrcan.gc.ca/fleetsmart

Transportation Research and Development: Canadian Lightweight Materials Research Initiative (CLiMRI)

Objective: To develop and implement low-density and/or high-strength materials (referred to simply as lightweight materials) in transportation applications for the purposes of reducing GHG emissions through improved vehicle efficiency and improving the competitive performance of the Canadian primary metals, automotive, truck, bus and rail-car manufacturing industries and their associated parts suppliers.

CLiMRI has targeted lightweight, high-strength materials and efficient design of components in vehicles through improved engineering performance of materials, improved manufacturing technologies and improved component and vehicle systems. Significant progress was made using all three strategies this year. NRCan continues to coordinate the activities for CliMRI.

Key 2001–2002 Achievements

- NRCan's Materials Technology Laboratory led USAMP's (U.S. Department of Energy) project on "Investigation of Corrosion Factor and Protection Methods" which forms part of its major "Structural Cast Magnesium Development Project."
- Several coatings for lightweight aluminum heat exchangers, including epoxy-based and experimental Sol-gel systems, were tested in simulated condensing and immersion heat exchanger environments. Initial results were favourable, and testing of heat exchanger prototypes will take place during 2002–2003.

Transportation Research and Development: Fuel-Cell-Powered Mining Vehicles

Objective: To develop the technology to replace diesel power by hydrogen fuel cell power in underground mining vehicles.

NRCan has taken a leadership role in this North American consortium. If this initiative is successful, Canada stands poised to capture world markets for applied fuel cell technology in mining – a clear example of the link between innovation and economic growth.

The application of fuel cell technology to underground mining by retrofitting diesel-powered vehicles would provide a number of benefits, such as eliminating underground diesel emissions and reducing heat and noise, improving the work environment for underground miners, reducing a significant portion of carbon dioxide emissions (1 million tonnes per year), giving the mining industry an opportunity to contribute to Kyoto Protocol emissions targets and decreasing operating costs by lowering mine ventilation needs by more than 35 percent (ventilation is responsible for 40 percent of the electrical consumption in an underground mine) and by significantly improving vehicle productivity (hydrogen-fuel-cell power systems are twice as efficient in delivering power as conventional diesel equipment).

Key 2001–2002 Achievements

- The prototype locomotive propelled with hydrogen fuel cells, the only example of its kind, has been undergoing surface testing by NRCan since the beginning of 2002, most recently at its experimental mine in Val-d'Or, Quebec. NRCan also provided the expertise of scientists and engineers who integrated the fuel cell with the locomotive and its control systems and conducted surface testing. The locomotive will be moved soon to the Placer Dome Inc. mine in Red Lake, in northwestern Ontario, for underground testing and evaluation. It is expected that many different types of vehicles, including underground diesel loaders – the mainstay of metal mine production – will eventually use this technology, and pilot projects are now underway in Canada, the United States and other countries.

Alternative Transportation Fuels: Vehicle Fuels

Objective: To increase Canada's fuel ethanol production and use and to support the use and development of fuel cell and natural gas vehicles.

Three elements within the program seek to meet its objective. (1) The Future Fuels Initiative increases the supply and use of ethanol by increasing Canada's ethanol production capacity. A contingent loan-guarantee program reduces the financial risk of new plant construction. Other activities include public education, economic and market analyses, research of standards and harmonization of policies where possible. (2) The Canadian Transportation Fuel Cell Alliance (CTFCA) is a private-public sector partnership program made up of technology developers, fuel providers, auto manufacturers, federal and provincial government officials, academia and non-governmental organization (NGO) representatives. The Alliance advances the adoption of fuel cell vehicles through the development of a supporting framework, including common technical standards, codes, training, certification and safety. (3) The Natural Gas for Vehicles Program, for regions of Canada served by Alberta natural gas, provides financial contributions for each factory-built natural gas vehicle, for dealers to sell new factory-built natural gas vehicles and for existing road vehicles converted to use natural gas, as well as a contribution to help foster new refuelling outlets, marketing and awareness activities and co-funded R&D.

Key 2001–2002 Achievements

- Estimated amount of fuel ethanol blended into motor gasoline per year reached 240 million litres in 2001.
- Royal Dutch/Shell Group of Companies, refinery sector, invested $46 million in Iogen Corporation's cellulose-based ethanol technology.
- Saskatchewan and Manitoba announced intent to pursue and/or consult on regulatory instruments for ethanol in gasoline; several provinces expressed interest in federal-provincial-territorial collaborative efforts to expand the ethanol industry.
- Memorandum of Understanding signed between the California Air Resources Board (CARB) and NRCan to facilitate information sharing on fuel cell and hydrogen research, development and demonstration,
- Formative meeting of the CTFCA held September 2001: 100 representatives of hydrogen and fuel cell industry, federal and provincial governments, fuel and equipment suppliers, NGOs, vehicle manufacturers, transit operators and colleges and universities.
- In 2001 model year, 290 natural gas vehicles sold in Canada, of which 48 were purchased by the Government of Canada; over 250 conversions of on-road vehicles.
- In fall 2001, 145 fuelling facilities available to the public.

For more information:
alt-fuels.nrcan.gc.ca

Alternative Transportation Fuels: Transportation Energy Technologies Program

Objective: In partnership with industry, to develop and deploy leading-edge transportation technologies that minimize environmental impacts, increase the potential for job and economic growth and extend the life span of Canada's energy resource base.

Program staff work with stakeholders in the domestic and international transportation industries, including original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the U.S. Department of Energy and the International Energy Agency.

- Over the last 15 years, work in partnership with Canada's fuel cell industry has established Canada as a world leader in fuel cell and refuelling technologies; for example, the world's first hydrogen fuel cell bus was demonstrated in Canada.
- Since the 1980s the program has supported student vehicle challenges, bringing university and college students from across North America together with automotive manufacturers to modify existing vehicles to run a variety of alternative fuels.
- The program has supported the development of alternative transportation fuel technologies, for example, for natural gas vehicles, which has led to a Canadian industry that is now exporting commercial products to foreign markets.

Key 2001–2002 Achievements

- Organized and sponsored world-class conferences, including the 11th Canadian Hydrogen Association Conference in 2001, the Canadian Hydrogen Storage Workshop and the 2001 Windsor Workshop.
- Launched the Canadian Transportation Fuel Cell Alliance, a $23-million program funded by the *Government of Canada Action Plan 2000 on Climate Change* for developing the fuelling infrastructure for fuel cell vehicles.
- Signed MOU with the CARB to exchange information on fuel cell technologies.
- Signed agreement with Stuart Energy Systems Corporation to develop a low-cost water electrolysis system for intermediate and large-scale energy applications.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_tet_e.html

Chapter 8: Renewable Energy

Introduction

Renewable energy sources are those that produce electricity or thermal energy without depleting resources. Renewable energy includes solar, wind, water, earth and bioenergy, including energy from waste.

Natural Resources Canada (NRCan) delivers several initiatives to encourage the development and use of emerging renewable energy sources and technologies. However, these initiatives do not apply to the following renewable energy resources:

- large-scale hydro-electricity, a well-established renewable energy source; and
- ethanol fuel production from agricultural feedstocks, which is covered under Agriculture and Agri-Food Canada programs.

Each renewable energy source depends on one or more energy production technologies, with their own level of economic attractiveness. Some technologies are mature and well recognized (e.g., hydro-electricity), others are emerging in the marketplace, and many are in the laboratory stage but offer promise for the long term. Renewable energy sources compete in many markets, including those for electricity, mechanical power, thermal energy (process heat, space heating and cooling and water heating and cooling) and transportation fuels (see Table 8-1).

Renewable Energy Use

In 1999, renewable energy generation capacity from renewable sources accounted for 62 percent of total Canadian electricity capacity (see Table 8-2). Most of the renewable energy used in Canada comes from either hydro-electricity or thermal energy from biomass such as wood-waste sources.

TABLE 8-1

Renewable Energy Markets and Technologies Used in Canada

Electricity	*Thermal Energy*
Hydro-electricity	Biomass (e.g., roundwood, pellets, wood chips)
Tidal power	Ground-source heat pumps (e.g., earth energy)
Biomass (e.g., wood waste)	Solar air-heating systems
Biogas (e.g., methane from landfill sites)	Solar hot-water systems
Wind turbines	
Photovoltaic systems	
Mechanical Power	*Transportation*
Wind water pumps	Ethanol from biomass

TABLE 8-2

Electricity Generation Capacity from Renewable Sources (includes hydro)

	Total renewable energy, petajoules	*% of total capacity*
1990	59 578	58
1991	61 137	58
1992	62 983	58
1993	63 202	56
1994	63 241	56
1995	66 742	57
1996	67 323	59
1997	68 406	61
1998	68 545	62
1999	68 849	62

Source: Stats Can 57-2012

Hydro-Electricity

Hydraulic power is a renewable energy based on the water cycle – evaporation, precipitation and flow of water toward the ocean. Canada has abundant water resources, and its geography provides many opportunities to produce low-cost energy. Tapping the energy from moving water has played an important role in the economic and social development of Canada for the past three centuries.

In 2001, hydro power accounted for approximately 58 percent of total electricity generation. Small-scale hydro-electric projects, with a capacity of 20 megawatts or less, constitute about 4 percent of Canada's electricity-generating capacity. Small-scale hydro has good potential for increased production.

Biomass

Bioenergy is a renewable source of energy derived from organic substances known as biomass. Biomass is supplied by agricultural wastes such as chaff, straw, grain screenings, husks and shells, food-processing residues and methane. Other biomass supplies include animal litter and manure, landfill gas methane, urban wastes to be incinerated and sewage for biogas. Bioenergy contributes about 6 percent of Canada's primary energy, mostly for industrial process heat, electricity generation and residential space heating. Corn and other agricultural products are also used to generate ethanol and biodiesels for the transportation market.

Bioenergy production represents Canada's second largest renewable energy source. Most bioenergy is produced from organic refuse and used with the facilities in which the energy conversion takes place. The pulp and paper industry produces and uses most of Canada's bioenergy. Industrially produced heat and electricity, independent power producers' electricity, electricity from urban wastes and residential wood heat are all considered commonplace in Canada's energy mix.

Home heating with wood usually takes the form of stand-alone wood stoves, water or forced-air wood furnaces, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters. About 3 million Canadian households use wood for home heating. Canadians usually prefer roundwood, but alternatives include wood chips and pellets.

Earth Energy

As a result of the sun heating the surface of the planet, the temperature of the earth that is one or two metres below the surface remains fairly constant – between 5°C and 10°C. This is warmer than outside air during the winter and cooler than outside air during the middle of summer. A ground-source heat pump takes advantage of this temperature difference by using the earth or the ground water as a source of heat in the winter and as a "sink" for heat removed from indoor air in the summer. For this reason, ground-source heat pumps are known as earth energy systems (EESs).

During winter, EES installations remove heat from the earth using a liquid, typically an antifreeze solution, that circulates within an underground loop. It then upgrades the heat with a conventional heat pump and transfers it to indoor space or the water heating system. During summer, the system reverses this process to operate as an air conditioner. EES installations supply less than 1 percent of the market for space and water heating and cooling in Canada.

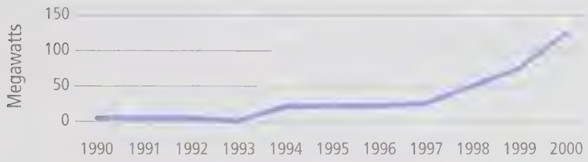
Wind Energy

Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada has a very large wind resource potential because of its large size and northern location. A 1992 NRCan study estimated the technical wind energy potential in Canada at about 28 000 megawatts. If developed, this could supply 11 percent of total Canadian electricity consumption. In 2001, wind energy accounted for less than 1 percent of Canada's total electricity generation.

Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie Provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses (see Figure 8-1).

FIGURE 8-1

Canadian Wind Power Capacity, 1990 to 2000



Solar Energy

Three main technologies use energy from the sun:

- passive solar technologies mean that buildings are designed and located to maximize their reception of solar energy;
- active solar thermal systems convert solar radiation into thermal energy for heating air or water in residential, commercial and industrial applications; and
- solar electric (photovoltaic) systems use solar radiation to produce electricity.

During the 1990s, NRCan assisted a Canadian company in developing a perforated solar absorber to preheat ventilation air and reduce a building's fuel requirements for space heating. This technology is much more cost-effective than conventional solar air heating technologies and is gaining acceptance in Canada and abroad. Systems have been installed on industrial, institutional and commercial buildings throughout Canada.

The installed photovoltaic (solar electric) capacity in 2001 was 8.1 megawatts, with an estimated annual production of 7.25 gigawatt hours of electricity. The bulk of this capacity is either "off grid" (not connected to an electrical transmission system), where the price of photovoltaics is competitive with conventional stand-alone power systems, or an extension of a grid to a given location. Typical applications include telecommunications systems, water pumping and purification, remote monitoring and control, remote residences, coast-guard lighting and beacon systems, and numerous consumer applications such as hand-held calculators. The Canadian Coast Guard is the largest individual user of photovoltaic systems in Canada, with an estimated 7000 navigational buoys, beacons and lighthouses. Canada has about 100 grid-connected photovoltaic systems, and they have a combined capacity of 315 kilowatts.

NRCan delivers several initiatives to increase the use of small-scale renewable energy in Canada. The following is the array of NRCan renewable energy programs, as well as an initiative in energy efficiency and renewable energy in Canadian communities.

Renewable Energy Programs: ENergy from the FORest (ENFOR)

Objective: To improve the understanding of the role of biomass production for energy and to improve biomass productivity in conventional forest stands and plantations.

ENFOR undertakes research and development on forest biomass for energy through the private sector, universities or Canadian Forest Service (CFS) research centres. Two primary sources of forest biomass for energy are under study: forest residues, including harvest residues; and energy plantations, involving short-rotation intensive culture in quick-growing trees, such as willow and poplar. ENFOR also supports research on information systems to determine the quantity and quality of biomass in Canadian forests. In effect since 1978, the ENFOR program has made a difference in forest science, knowledge and understanding of forest biomass production and the technology to increase the use of forest bioenergy. It does this by encouraging a different look at the world and by removing the barriers to increase the use of biomass.

- ENFOR successes include the *Forest Biomass Inventory of Canada*; the FORest nutrient Cycling and Yield Trend Evaluator (FORCYTE) model; the understanding of whole-tree harvesting and nutrient cycling; the CFS Carbon Budget Model; the development and testing of species, clones and production technologies for energy plantations; and technology transfer.

Key 2001–2002 Achievements

- Collaboration in international projects on forest biomass – workshops, seminars and publications have been the primary products.
- Evaluation of biomass plantations – Evaluation of the productivity of a willow biomass plantation farm, including growth, productivity, insect and disease damage, nutrients and public acceptance provided the information to assess the sustainability of such operations.
- Workshop on Agricultural and Forestry Biomass Supply for Energy – Attendees from CFS, NRCan, Agriculture and Agri-Food Canada, Environment Canada, universities and industry reviewed the state of the science of biomass supply and determined the gaps and defined strategic directions needed in bioenergy research.

For more information:
nrcan.gc.ca/cfs-scf/science/fundprog/enfor_e.html

Renewable Energy Programs: Green Power Initiative

Objective: To reduce greenhouse gas and other air pollution emissions associated with federal electricity consumption by purchasing electricity from emerging renewable energy sources that are certified by a third party as having low environmental impact.

Under the Green Power Initiative, NRCan purchases electricity generated from renewable energy sources and encourages other federal departments to do the same. NRCan has pledged to purchase 20 percent of its electricity from new green power sources by 2010, wherever it makes economic sense. NRCan made its first green power purchase in Alberta in 1998.

Key 2001–2002 Achievements

- The Government of Canada began receiving electricity from emerging renewable energy sources in Saskatchewan and Prince Edward Island in 2001.
- The government of Prince Edward Island is purchasing electricity from emerging renewable energy sources for its own facilities.
- The 5.3-megawatt wind farm in Prince Edward Island was built in the fall of 2001.
- A Memorandum of Understanding with Nova Scotia Power was extended to allow for continuing negotiations toward a purchase of electricity.

For more information:
nrcan.gc.ca/redi

Renewable Energy Programs: Photovoltaic and Hybrid Systems Program

Objective: To support the development and application of solar photovoltaic (PV) technologies in Canada.

Program expertise is available for technical and economic studies for PV systems, the development and testing of PV systems components, the design and optimization of PV-genset hybrid systems and their application in cold climates, the development of product standards and electrical installation codes and the development of advanced modelling and simulation software tools. The program also supports the development of grid-connected applications in Canada, including the building of integrated PV systems.

- Growth of PV applications in Canada has averaged 25 percent per year over the last eight years, with an installed power capacity reaching 8.1 megawatts in 2001. PV systems have been shown to operate reliably in many remote and off-grid applications in Canada.

Key 2001–2002 Achievements

- Signed an agreement to develop and demonstrate the first community-scale PV system integrated to residential rooftops in a neighbourhood in Canada (Kitchener-Waterloo, Ontario).
- Launched MicroPower Connect, with key players from industry and other federal departments, addressing the interconnection of issues of small distributed power sources (www.micropower-connect.org).
- Developed and hosted the international "Workshop on the Use of Photovoltaic Power Systems in Developing Countries" and the international "PV Horizon: Workshop on Photovoltaic Hybrid Systems."
- Safety improved for solar PV equipment and for the installation of PV power sources because of changes to the CSA C22.2 No. 107.1 ("General Use Power Supplies") standard and the *Canadian Electrical Code*.

For more information:
cetc-varennes.nrcan.gc.ca/eng/programmes_energies.html#photovoltaique

Renewable Energy Programs:
Renewable Energy Capacity-Building Program

Objective: To promote the deployment of renewable energy systems by building the capacity of planners, decision-makers and industry to implement more projects successfully.

The Renewable Energy Capacity-Building Program (RECAP) works to create knowledge through the development of enabling tools, knowledge transfer to clients and providing project implementation support in high-priority markets, such as Canadian remote communities and federal facilities.

- Since the initial release of the software in May 1998, the RETScreen® International Renewable Energy Project Analysis Software has more than 20 000 users in 185 countries. Demand for the software has been growing at more than 150 new users per week. In 2001 the RETScreen® Web site had more than 4 million "hits."

Key 2001–2002 Achievements

- RECAP team received the 2001 Head of the Public Service Award for Excellence in Service Delivery. The team developed the RETScreen® International Renewable Energy Project Analysis Software, working with a network of experts from across Canada and around the world.
- Trained more than 650 Canadians at 25 renewable energy training seminars across the country in collaboration with the Renewable Energy Deployment Initiative, the Federal Buildings Initiative and the Aboriginal and Northern Climate Change Program.
- Provided project implementation support to more than 50 potential renewable energy projects at federal and municipal government facilities and in Aboriginal and northern communities.

For more information:
retscreen.net

Renewable Energy Programs: Renewable Energy Deployment Initiative (REDI)

Objective: To stimulate the demand for renewable energy systems by helping the supply industry in its marketing and infrastructure development efforts, including the provision of financial incentives.

REDI targets four systems: solar water-heating, solar air-heating, earth energy and high-efficiency, low-emissions biomass combustion. REDI promotes these systems in the business, federal and non-business markets, mainly through financial incentives, marketing and infrastructure development.

Key 2001–2002 Achievements

- $1.2 million in REDI financial incentives was distributed among a total of 49 projects valued at $5.5 million; the projects were completed in 2001–2002.
- Officially announced the new CSA standard C448 Series-02, "Design and Installation of Earth Energy Systems."
- Helped a federal organization and other entities to implement their renewable energy initiatives, including an innovative project for an ocean geothermal heat pump system.

TABLE 8-3

REDI for Business Projects Completed

	Number of projects completed	*NRCan contribution*
1998 – 1999	8	$141,055
1999 – 2000	9	$119,910
2000 – 2001	24	$1,849,918
2001 – 2002	49	$1,202,259
Total	**90**	**$3,313,142**

- Completed three solar pool-heating pilot projects in Quebec, Ontario and British Columbia to promote the use of unglazed solar collectors for residential pools.

For more information:
nrcan.gc.ca/redi

Renewable Energy Programs: Renewable Energy Information and Awareness Program

Objective: To expand the use of renewable energy technologies and stimulate the growth of the renewable energy industry.

Program activities focus on examining the information needs of market participants (i.e., potential users of renewable energy and the renewable energy industry) and preparing specialized information to show how renewable energy technologies can economically and reliably help meet Canada's energy needs.

Key 2001–2002 Achievements

- Introduced, sometimes in collaboration with allies, several new publications on renewable energy technologies, including
  - *An Introduction to Photovoltaic Systems*
  - *Photovoltaic Systems: A Buyer's Guide*
  - *Discover the Uses of Landfill Gas*
  - *Residential Earth Energy Systems: A Buyer's Guide*
  - *Earth Energy Case Study: Ground-source heat pumps produce savings for commercial building*
- Held five workshops in various regions to raise awareness and encourage renewable energy technology in the institutional and commercial sectors, including in national parks.
- Sponsored two geoexchange workshops in March 2002 to address questions related to the capabilities and efficiencies of geoexchange systems.

For more information:
canren.gc.ca

Renewable Energy Programs: Renewable Energy Market Assessment Initiative

Objective: To review renewable energy resources and use and to determine the potential market for commercially available technologies for meeting Canada's energy needs and environmental goals.

Initiative activities include compiling data on demand and supply constraints, evaluating market prospects for existing and new technologies and developing strategies to increase the capacity of the renewable energy industry to meet demand in identified markets.

Key 2001–2002 Achievements

- Eight residential wood-heating pilot projects took place across Canada, with the educational portion sponsored by NRCan, to encourage Canadians to burn wood cleaner, safer and more efficiently.
- Conducted three workshops for the advancement of solar energy and other renewable energies in national parks. A network of parks' renewable energy champions was initiated, and negotiations are ongoing to incorporate renewable energy into park operations.
- Worked with the Canadian Electricity Association and the Geothermal Heat Pump Consortium, Inc. to consolidate efforts in the promotion of geoexchange systems.

For more information:
nrcan.gc.ca/redi

Renewable Energy Programs: Renewable Energy Technologies Program

Objective: To support efforts by Canadian industry to develop renewable energy technologies.

Technologies supported include bioenergy (combustion, biochemical conversion of biomass to ethanol, thermo-chemical conversion of biomass to bio-oil and biogas, and biomass preparation and handling), small hydro projects (less than 20 megawatts), active solar applications and wind energy. Activities are directed toward improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users and helping industry commercialize its products in domestic and foreign markets.

- With ongoing support from NRCan dating back to the early 1980s, Conserval Engineering Inc. developed SOLARWALL® – the world's most efficient solar air heating system.
- With NRCan and other federal support, Iogen Corporation developed and demonstrated a cost-effective process for the production of ethanol from biomass, including existing agricultural residues. Iogen anticipates this technology will lead to the widespread use of 10 percent ethanol, blended with gasoline, as a motor vehicle fuel in Canada.

Key 2001–2002 Achievements

- NRCan's new 200-kilowatt indoor solar simulator lamp, the world's largest, opened for business at the National Solar Test Facility – North America's leading centre for testing and rating technologies under controlled sunlight and temperature conditions.
- Signed agreement with Vergnet SA of France to transfer its 10- and 60-kilowatt wind turbine technology to its new subsidiary, Vergnet Canada Ltd., so that the turbines will be manufactured in Canada.
- Université Laval's Mechanical Engineering small hydro turbine laboratory test-bench facility, developed in partnership with NRCan, expanded its analysis capacity.
- Established a Web site for the Canadian Renewable Energy Network.

For more information:
cetc-varennes.nrcan.gc.ca/eng/programmes_energies.html

Community Energy Systems: Community Energy Systems Program

Objective: To increase the sustainability of Canadian communities by addressing their energy needs.

In partnership with Canadian communities and businesses, energy needs are addressed through a holistic approach to energy efficiency, renewable energy and community energy planning.

- NRCan has supported many district energy projects, some of which are based on renewable energy, including Charlottetown, Prince Edward Island – biomass and municipal waste fuelled; Fort McPherson, Northwest Territories – cogeneration; Cornwall and Sudbury, Ontario – cogeneration; Windsor and Hamilton, Ontario – cogeneration, heating and cooling; Ajax, Ontario – using waste wood from industry; and Watson Lake, Yukon Territory, and Arviat, Nunavut, and many other northern communities – using waste energy from the local power plants.
- NRCan helped design a heating system for the Cree community of Oujé-Bougoumou, in northern Quebec. The system uses sawdust from a local sawmill to provide over 90 percent of the energy required using oil as a backup. Carbon dioxide emissions have been reduced by an estimated 2300 tonnes per year.

Key 2001–2002 Achievements

- Developed a community energy training program and piloting of workshops in Regina, Saskatchewan, and Halifax, Nova Scotia.
- Sponsored the Canadian District Energy Association Conference, focusing on raising awareness of the benefits of district energy.
- Published technical guidebook *District Energy – Biomass and Your Community*, covering initial steps in assessing the feasibility of biomass district energy.
- Produced two International Energy Agency reports: *District Heating and Cooling Connection Handbook* and *Optimization of District Heating Systems by Maximizing Building Heating System Temperature Difference.*
- Sponsored, with U.S. Department of Energy, the 2nd Annual Workshop on Microturbine Applications. Microturbines offer increased energy efficiency and potential to generate heat and power on-site.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_ces_e.html

Chapter 9: Federal House in Order

Introduction

The Government of Canada is the country's largest single enterprise. It is working to get its own house in order by setting a target of 31 percent reduction in greenhouse gas (GHG) emissions from its own operations by 2010.

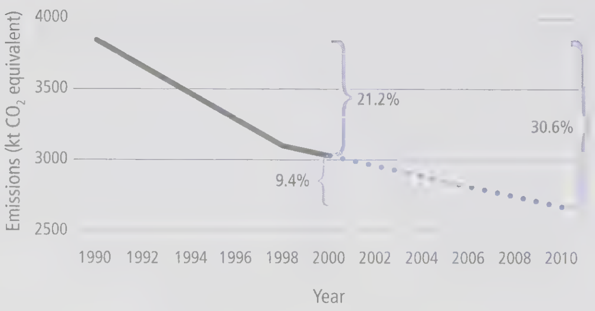
Since 1990, through building retrofits, better fleet management, strategic "green power" purchases and the downsizing of operations, the Government of Canada has already achieved a 21 percent emissions reduction. The Government of Canada will reduce its emissions by a further 12 percent by 2010.

The Government of Canada will achieve its goal by additional building retrofits, fuel switching and increased use of renewable energy within government operations. Moreover, the government can help to "create the market" for certain new technologies on the verge of becoming viable. Key departments, which are responsible for 95 percent of government GHG emissions, have been assigned specific targets and must report annually on their progress.

The task of target sharing has been undertaken by means of a three-year action plan and entails assigning specific targets to the 11 key departments. Natural Resources Canada (NRCan) is taking a lead role in managing this task and in providing the services to departments and agencies that will help them achieve their targets. The Leadership Challenge encourages the reduction of all federal emissions by engaging the active participation of the departments, agencies and Crown corporations that were not designated with a target.

FIGURE 9-1

GHG Emissions Reductions from All Federal Operations



The Federal House in Order initiative consists of various complementary activities, including GHG inventory and tracking, purchases of emerging renewable electricity or Green Power and efforts to reduce "outside emissions" (a pilot project for transit pass through payroll deduction for federal employees was launched October 2002), and three supporting programs:

- Federal Buildings Initiative;
- Federal Industrial Boiler Program; and
- Federal Vehicles Initiative.

Federal Buildings Initiative (FBI)

Objective: To assist Government of Canada departments and agencies to implement energy efficiency improvements, leading to reduced GHG emissions and operating costs.

The FBI provides services to help implement comprehensive energy efficiency improvements. These include advice and consultation on organization readiness and project design; lists of energy management firms qualified to build projects; project financing options; a national network for energy management training; model tendering documents; and employee awareness products.

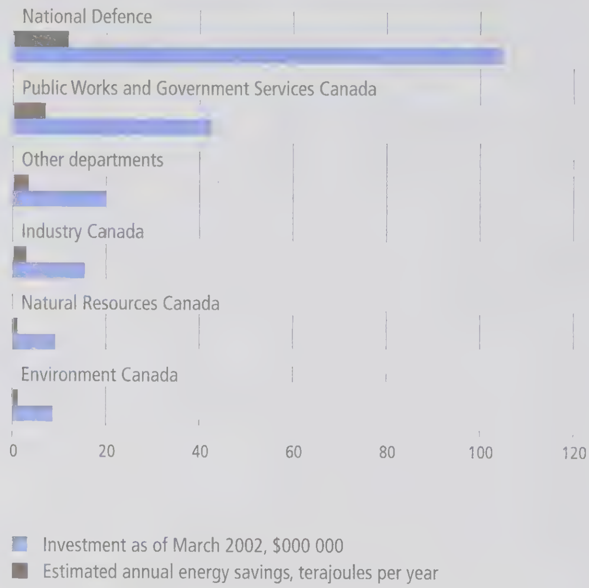
Key 2001–2002 Achievements

- Initiated and registered retrofits of 7000 federal buildings and other facilities, reducing GHG emissions significantly and generating annual savings of $27 million.

For more information:
oee.nrcan.gc.ca/fbi/home_page.cfm

FIGURE 9-2

FBI Investment and Energy Savings



Federal Industrial Boiler Program (FIBP)

Objective: To help clients increase energy efficiency, reduce carbon dioxide (CO_2) and nitrogen oxide (NO_x) emissions and extend the useful life of existing heating and cooling systems.

FIBP encourages its clients to consider energy-efficient and environmentally responsible technologies when replacing or modifying central heating and cooling plants. Services delivered under FIBP help government departments and other clients adopt new heating and cooling technologies that could reduce NO_x emissions by 50 percent, increase energy efficiency by up to 15 percent and reduce operating costs by 20 percent, compared with conventional practices.

- FIBP clients have reduced energy consumption by 800 terajoules, CO_2 emissions by 45 kilotonnes and NO_x emissions by 100 tonnes.

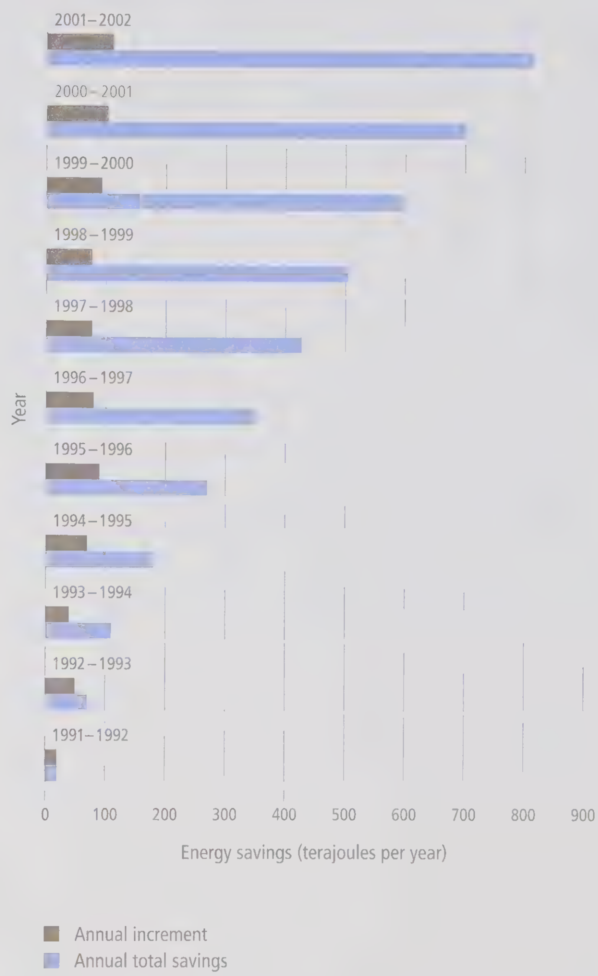
Key 2001–2002 Achievements

- Public Works and Government Services Canada (PWGSC) and Health Canada optimized their boiler systems and were given alternatives for humidification.
- Optimized building mechanical systems at Canadian embassies – in New Delhi, India; Washington, D.C., United States; and Tokyo, Japan.
- Coordinated installation of a standby power facility for Agriculture and Agri-Food Canada (AAFC), including new building construction and installation of two diesel-fired generators.
- Identified energy saving opportunities (cogeneration, lighting, building automation controls) for Communications Research Centre Canada, Shirleys Bay, Ontario.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_fibp_e.html

FIGURE 9-3

Energy Savings from FIBP, 1991–1992 to 2001–2002



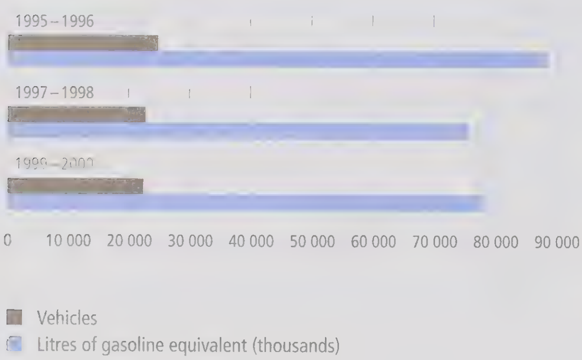
Federal Vehicles Initiative

Objective: To assist Government of Canada departments increase the energy efficiency of their motor vehicle fleets, reduce the environmental impact of federal vehicle operations and promote the *Alternative Fuels Act* within the federal fleet.

The Initiative provides fleet managers with an assessment of fleets as well as technical advice and encouragement on acquiring and using alternative transportation fuels (ATFs). Four departments participate in planning and reporting on the initiative: Treasury Board of Canada Secretariat, NRCan, Environment Canada and PWGSC.

FIGURE 9-4

Federal Fleet Size and Fuel Consumption, 1995–1996 to 1999–2000



Key 2001–2002 Achievements

- Agreement with Canada Safety Council to include energy efficiency content in the 2002 version of the Defensive Driving Course; Department of National Defence, Canadian Food Inspection Agency/AAFC and Correctional Service of Canada to use this course for all drivers.
- By fall 2001, three new executive vehicles using ATFs.

For more information:
oee.nrcan.gc.ca/greening

FIGURE 9-5

Purchase of ATF Vehicles for the Federal Fleet

Chapter 10: Intergovernmental Cooperation

Introduction

This chapter describes Natural Resources Canada's (NRCan's) intergovernmental cooperation with respect to efficiency and alternative energy (EAE) during the reporting period at three levels: municipal, provincial/territorial and international. Other examples of intergovernmental cooperation are set out in previous chapters in the Key Achievements sections of specific EAE program initiatives.

Federal-Provincial and Federal-Territorial Cooperation

Provincial and territorial governments delivered a substantial number of EAE programs during the reporting period in order to reduce energy costs, increase competitiveness, improve air quality and generate economic and trade opportunities. Coordination between the federal and provincial/territorial levels is essential to avoid duplication and ensure efficient program delivery. During the reporting period, the governments cooperated at the general level and at the level of specific program initiatives.

General Cooperation

Cooperation Agreements

- NRCan had a Letter of Cooperation (LOC) on EAE with the Agence de l'efficacité énergétique du Québec during the reporting period. The LOC ensures an efficient consultation and exchange of information between the two governments, and it helps coordinating EAE activities in the province and creating opportunities for joint projects. The management committee established under the LOC met twice a year during the period to review policy and program developments, progress on joint program initiatives and areas for further cooperation.
- The LOC played a considerable role in facilitating the conduct of three activities in particular:
  - the management of the licensing agreement for the EnerGuide for Houses Program (which is delivered in Quebec by the Agence de l'efficacité énergétique);
  - the conclusion of a contribution agreement between NRCan's Office of Energy Efficiency (OEE) and the Agence de l'efficacité énergétique under the Commercial Building Incentive Program regarding projects submitted to NRCan by public organizations in Quebec. The cooperation framework that was agreed upon in February 2000 is now being applied to other NRCan energy sector programs aimed at the public sector in Quebec; and
  - the management of the agreement between NRCan (CANMET Energy Technology Centre – Varennes, Quebec) and the Agence de l'efficacité énergétique relating to the Programme d'intervention en réfrigération dans les arénas du Québec. Among activities, an important study was completed to evaluate the potential energy savings and greenhouse gas emissions reduction in Quebec's arenas.
- Another LOC on energy efficiency and renewable energy was signed in 2001 between the Government of Canada and the Government of Yukon with similar objectives, i.e., facilitating information exchange and creating opportunities for joint projects in Yukon Territory. The first project under the LOC was the creation of a joint Energy Solutions Centre in Whitehorse, Yukon Territory, which started its operations in December 2000. The Centre provides access to relevant technical services to the Yukon population, undertakes outreach and public education activities and delivers assigned energy efficiency and renewable energy programs in Yukon Territory.

National Advisory Council on Energy Efficiency (NACEE)

- NRCan created NACEE in April 1998 to advise and guide the OEE on the most effective way to achieve its mission. During 2001–2002, NACEE members included representatives from four provinces – Manitoba, New Brunswick, Quebec and Saskatchewan – who had the opportunity to comment on the OEE's business plan and programs.

Cooperation at the Program Level

R-2000 Initiative

- In 2001–2002, the R-2000 Initiative was delivered in seven provinces (Alberta, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario and Saskatchewan) and in Yukon Territory. Provincial home builders' associations, except in Manitoba and Yukon Territory, participated in the delivery of the program. There were three types of cooperation during the period:
  - Representatives from most provinces and Yukon Territory participated as members of regional R-2000 advisory committees;
  - In New Brunswick, Newfoundland and Labrador, Nova Scotia and Saskatchewan, the provincial governments and NRCan supported the program through financial or in-kind contributions; and
  - In Manitoba and Yukon Territory, the provincial and territorial governments delivered the program under a licensing agreement with NRCan.

EnerGuide for Houses Program

- Several provinces and Yukon Territory participated in the EnerGuide for Houses Advisory Committee.
- Yukon Housing Corporation and the Agence de l'efficacité énergétique du Québec are the delivery agents of the program in their jurisdictions, under licensing agreements with NRCan.

Federal Buildings Initiative (FBI)

- British Columbia and New Brunswick have replicated a number of elements of FBI into programs aimed at improving the energy efficiency and environmental performance of their buildings inventories.

Commercial Building Incentive Program (CBIP)

- Provinces and territories distributed information on CBIP. Provincial and territorial health and education departments were active participants in the program as eligible parties.

Canadian Industry Program for Energy Conservation (CIPEC)

- The excellence of the CIPEC concept and its ability to instigate positive change was affirmed when India chose the CIPEC model as the basis for the Indian Industrial Programme for Energy Conservation (IIPEC). Following CIPEC's lead, IIPEC is establishing a series of energy management sector task forces, including cement, pulp and paper and textiles.

In April 2002, representatives of IIPEC toured Canadian facilities of CIPEC partners in Ontario and Quebec, joined a CIPEC Cement Task Force meeting and met with officials from the OEE and other federal departments, non-governmental organizations, academia and research labs. Two participants from the Indian delegation attended an OEE customized "Dollars to $ense" textile workshop.

Energy Innovators Initiative (EII)

- EII relies on partners to promote energy efficiency and facilitate access to its members as well as to provide sectoral information. Partners include the Association of Canadian Community Colleges, the Canadian School Boards Association, the Canadian College of Health Service Executives, the Association des gestionnaires de parcs immobiliers institutionnels, the Hotels Association of Saskatchewan, the Alberta Hotel & Lodging Association, the Manitoba Hotel Association and the British Columbia & Yukon Hotels' Association. As well, a dynamic partnership has been established with BC Hydro to assist in identifying new retrofit projects with large energy users. Additionally, the EII works with the Agence de l'efficacité énergétique du Québec to facilitate program delivery to the province's institutional sector.

Equipment Energy Efficiency Regulations

- NRCan and five provinces (British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec) regulate the energy efficiency performance of prescribed equipment. They share information and consult through CSA International's Advisory Committee on Energy Efficiency.

Green Power Initiative

- The February 2000 federal budget announced that the Government of Canada would expand the pilot Green Power Initiative to procure $15 million of renewable energy over the next 10 years in Saskatchewan and Prince Edward Island. NRCan entered into discussions with SaskPower and Maritime Electric on the purchase of green power for federal facilities in the provinces they serve.

Residential Wood Combustion

- NRCan is a member of the Intergovernmental Working Group on Residential Wood Combustion, which is co-chaired by Environment Canada and the Newfoundland and Labrador Department of Environment. The Federal Smog Management Plan calls for four initial joint actions on residential wood combustion:
  - assess the effectiveness of pilot wood-stove change-out programs and consider options for a national program;
  - complete an update of CSA International standards on wood stoves, fireplace inserts and solid-fuel-burning central systems, and further the development of similar standards for fireplaces;
  - support public education on cleaner wood burning with advanced technologies and sustainable wood use; and
  - develop a federal regulation on residential wood combustion, focusing on cleaner-burning appliances.
- NRCan chairs the cross-jurisdictional steering committee developing a Canada-wide education campaign on safe, clean and efficient residential wood heating. NRCan worked with health industry partners, the Canadian Lung Association, the Canadian Environmental Network and Fire Prevention Canada in preparation of the initial launch of the campaign in fall 2002.

Personal Vehicle Program

- NRCan successfully partnered with the City of Mississauga, Ontario, to pilot a municipal-based awareness campaign promoting the benefits of not idling vehicles needlessly. The two-year pilot will lay the groundwork for a national campaign, which will also provide municipalities, community groups and individuals with a "tool kit" of information to launch their own anti-idling campaigns.
- NRCan collaborated with the Agence de l'efficacité énergétique du Québec, along with federal and industry partners, on a series of citizen engagement forums across the country. The goal of the forums was to identify barriers and motivators that could help Canadians reduce the environmental impacts of their driving while also reducing their transportation costs.

Federal-Municipal Cooperation

- The town of Banff, Alberta, mandated the R-2000 Standard for new residential construction by the Banff Housing Corporation.
- A number of municipalities received financial incentive contributions in 2001–2002 under CBIP.
- A number of municipalities registered as Energy Innovators during the period, and some received financial assistance under the EII.

Green Municipal Funds

- The Green Municipal Funds were created in Budget 2000 by an endowment of $125 million to the Federation of Canadian Municipalities (FCM). The funds were doubled in Budget 2001 to the current total of $250 million – $50 million for the Green Municipal Enabling Fund (GMEF) and $200 million for the Green Municipal Investment Fund (GMIF).

- Cooperation takes place on several levels in the delivery of the Green Municipal Funds:
  - The Government of Canada signed an Agreement with the FCM, a non-profit organization, to deliver the Green Municipal Funds.
  - Moneys for the Green Municipal Funds endowment were provided equally by NRCan and Environment Canada who signed a Memorandum of Understanding.
  - Provincial, territorial and municipal officials cooperate to promote projects with innovative environmental solutions within municipalities across Canada because each municipal application must be accompanied by a provincial or territorial letter of support.
  - The Government of Canada shares in the governance of the Green Municipal Funds, along with representatives from both the public and private sectors, including municipal officials and technical experts, through participation on a Peer Review Committee and a governing Council.

International Cooperation

NRCan also cooperates with several international organizations and foreign governments. Canada benefits from this cooperation in two ways:

- Canada learns about improved ways of designing and delivering EAE programs; and
- this cooperation helps to reduce trade barriers to energy-using products through the harmonization of energy efficiency tests and performance standards.

International Energy Agency (IEA)

Canada is a member of the IEA, an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD).

On the policy side, NRCan serves on a number of committees that review policies and undertake studies on energy efficiency and related issues. These committees include the Standing Group on Long-Term Cooperation (SLT) and the Energy Efficiency Working Party (EWP), which reports to the SLT. The SLT develops policy analyses to promote conservation and the efficient use of energy, whereas the EWP/SLT carries out more detailed studies on specific energy efficiency issues.

Canada is an active member of the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET). CADDET is an international information network to help managers, engineers, architects and researchers find out about energy-using technologies that have worked in other countries. Canada cooperated with some 11 OECD countries during the reporting period.

Canada also collaborates with research centres in member countries on several agreements and programs of the IEA oriented toward research and development (R&D) and technology.

Asia-Pacific Economic Cooperation (APEC)

Since the first meeting of APEC Energy Ministers in August 1996, NRCan has played a leading role in efforts to ensure that efficiency test standards for energy-using appliances do not become barriers to trade within the APEC region. Acting on the ministers' directions, NRCan has chaired the APEC Energy Working Group's Steering Group on Energy Standards since 1996. In 2000, the work plan of this working group was incorporated into that of the Expert Group on Energy Efficiency and Conservation.

During the reporting period, the group started investigating the prospects for developing ways to determine energy performance by one test procedure (from the results generated by testing another test procedure). This investigation focused on domestic refrigerators and air conditioners. Additional studies were initiated to survey manufacturers and regulators regarding the acceptance of these results. Reports are expected to be finalized in the third quarter of 2001/2002.

Also under the APEC Energy Working Group, NRCan participates in the Expert Group on New and Renewable Energy Technologies. Activities of the working group during the reporting period included exchanging information on new and renewable energy technology programs, technologies and R&D strategies; fostering cooperation in priority areas; conducting technology transfer seminars; analysing projects for APEC funding; and monitoring progress in the accepted projects. On the domestic side, NRCan provided information to interested Canadian parties in the private sector and government on opportunities for collaboration, potential opportunities for technology transfer and information exchange, and upcoming APEC seminars.

Hemispheric Energy Initiative

The Hemispheric Energy Initiative (HEI) is the energy component of the action plan arising from the Summit of the Americas and supporting the Hemispheric Energy Ministers meetings. The aim of the HEI is to advance sustainable development and use of energy in the hemisphere. The HEI has eight "outcomes," one of which is promotion of energy efficiency in the hemisphere. NRCan leads one component of this outcome – promotion of energy efficiency in equipment and buildings.

Research and Development

NRCan facilitates R&D and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities, including participating in various IEA tasks and supporting technical and trade-oriented workshops and conferences.

Mexico

NRCan signed a Memorandum of Understanding (MOU) on EAE cooperation with the Mexican Energy Secretariat in June 1996. The objective of the MOU is to contribute to the EAE objectives of both countries by

- improving the design and delivery of EAE programs implemented or sponsored by NRCan and Mexico's National Commission for Energy Savings (Comisión Nacional para el Ahorro de Energía [CONAE]); and
- enhancing trade, investment and exchanges (technical and other) related to energy-efficient products, energy management services and alternative energy goods and services.

Bangladesh

NRCan and Environment Canada led a technical training project with the Bangladesh State Gas Company, at the request of the Government of Bangladesh. An agreement was signed with BC Gas International Inc. to provide technical training to personnel from Bangladesh on the use of compressed natural gas as a transportation fuel. Funding was provided by the United Nations Development Programme with extensive in-kind contributions coming from Canadian industry.

Poland

NRCan, through the Program of Energy Research and Development, is supporting a small hydro project in Poland. The project also received financial support from the Technology Early Action Measures (TEAM) component of the Climate Change Action Fund. Located on the Odra River, near Opole, Poland, the three-site project will provide 4.5 MW of energy and is expected to be completed and commissioned by June 2004. The project is a joint venture between a Canadian partner (ESI Ecosystem International ltd.) and a Polish partner (Pump Storage Power Plants Co.).

United Kingdom

NRCan, working with Canada Mortgage and Housing Corporation, the Canadian High Commission, a Canadian builder and a U.K. builder, brought the Super E™ housing program to the United Kingdom. Herb Dhaliwal, the Minister of Natural Resources Canada, officially opened the first house, with many more being built. The Super E™ House Program is a strategic housing export initiative delivered by NRCan as part of the Team Canada Inc. export strategy.

United States

Motor Vehicle Fuel Efficiency and Fuels – In March 1996, NRCan and the U.S. Department of Energy signed an MOU concerning road transportation, energy efficiency and alternative fuels. The MOU provides a formal mechanism for negotiating and harmonizing North American policy on fuel efficiency, as both nations consider options in responding to their respective climate change commitments.

Three important studies are now being conducted under the MOU. The first study aims at developing an analytical framework for estimating the technological response to any new initiative to improve the fuel economy of future new vehicles, and applying the framework to assess the impact on three selected manufacturers and their products. The second study analyses the emissions reduction potential of gas and diesel engines in North America. The third study analyses the potential costs and benefits of the 42-volt hybrid system for vehicles.

United States and Mexico

NRCan participates with the United States and Mexico in the North American Energy Working Group's Energy Efficiency Experts Group to promote the harmonization of energy efficiency test methods, mutual recognition of conformity assessment systems for energy efficiency standards and cooperation on trilateral energy efficiency labelling programs. During the review period, test standards for three products were assessed, and equivalent standards of performance were then instituted in Mexico. Work has begun to determine the prospects for the participation of Mexico in the ENERGY STAR® high-efficiency program currently promoted in Canada and the United States.

Appendix 1:
NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 2001–2002

Program	(millions of dollars)
General Programs	**6.22**
Outreach	
National Energy Use Database	
Community Energy Systems Program	
Energy Efficiency – Equipment	**5.26**
Energy Efficiency Standards and Regulations	
Labelling and Promotion	
EnerGuide for Houses	
EnerGuide for Industry	
Mine Ventilation	
Water-Powered Hydraulic Drill	
Energy Efficiency – Buildings*	**35.52**
R-2000 Standard	
Super E™ Program	
Commercial Building Incentive Program	
Industrial Building Incentive Program	
Federal Buildings Initiative	
Federal Industrial Boiler Program	
Green Buildings	
Energy Innovators Initiative	
Buildings Program	
Simulation	
Bringing Energy Efficient Technologies to Market	
Energy Efficiency – Industry	**38.69**
Industrial Energy Efficiency (Canadian Industry Program for Energy Conservation; Industrial Energy Innovators)	
Advanced Combustion Technologies	
Processing and Environmental Catalysis Program	
Industrial Process Engineering Program	
Industrial Process Integration Program	
Industry Energy Research and Development Program	
Emerging Technologies Program	
Energy Technologies for High-Temperature Processes	
International Centre for Sustainable Development of Cement and Concrete	
Energy Efficiency – Transportation	**12.46**
Vehicle Efficiency Targets	
Personal Vehicle Program	
Fleet Vehicle Program	
Federal Vehicles Initiative	
Canadian Lightweight Materials Research Initiative	
Alternative Energy – Transportation	**3.90**
Fuel-Cell-Powered Mining Vehicles	
Vehicle Fuels	
Transportation Energy Technologies Program	
Alternative Energy – Renewable Energy Sources	**17.31**
ENFOR (ENergy from the FORest)	
Green Power Initiative	
Photovoltaic and Hybrid Systems Program	
Renewable Energy Capacity-Building Program	
Renewable Energy Deployment Initiative	
Renewable Energy Information and Awareness Program	
Renewable Energy Market Assessment Initiative	
Renewable Energy Technologies Program	
Total*	**119.36**

*In addition to the resources cited here, $12.5 M and $50 M were provided to the Green Municipal Enabling Fund and the Green Municipal Investment Fund, respectively, which are managed by the Federation of Canadian Municipalities.

Appendix 2:
Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for the purpose of energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix C of NRCan's *Energy Efficiency Trends in Canada 1990 to 1999*.

FIGURE 2-1: Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.98	1.00	1.02	1.06	1.07	1.11	1.12	1.09	1.13	1.17
Energy use without efficiency improvement	1.00	0.99	1.02	1.05	1.09	1.12	1.15	1.17	1.16	1.21	1.26

FIGURE 2-2: Net Solar, Wind, Wood and Waste Electric Power Consumption in Canada

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Terawatt hours (billions of gigawatt hours)	missing	4.1	4.5	5.4	5.3	5.5	5.9	6.3	7.0	9.0

FIGURE 4-1: Canadian Households by Type of Dwelling, 2000 (percent)

Single detached	55.53
Apartments	31.68
Single attached	10.60
Mobile homes	2.19

FIGURE 4-2: Residential Energy Use by Purpose, 2000 (percent)

Space heating	62.73
Water heating	20.38
Appliances	11.18
Lighting	4.88
Space cooling	0.82

Figure 4-3: Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.04	1.12	1.08	0.98	1.02	1.07
Energy use without efficiency improvement	1.00	1.04	1.10	1.14	1.15	1.17	1.22	1.19	1.10	1.15	1.22

FIGURE 4-4: Annual Heating Costs for Houses Constructed to Different Standards, 1999 (dollars per year)

Typical existing house (1970)	1790
Typical new house (1999)	1134
Model National Energy Code house (1999)	897
R-2000 house	701

FIGURE 4-5: Average Energy Consumption per Household (EnerGuide for Houses Program and R-2000 Initiative) (gigajoules)

Year Built	Average Energy Consumption	Average EGH Rating
R-2000	96.91	81.61
Canada	198.70	62.49
2001–2010	132.61	74.46
1991–2000	148.20	71.61
1981–1990	180.57	66.91
1971–1980	191.86	63.80
1961–1970	196.89	62.64
1946–1960	206.54	60.91
Pre-1946	272.33	49.68

FIGURE 4-6: R-2000 Share of National Housing Completions, 1990 to 2000 (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
R-2000 Share	0.279	0.333	0.673	0.959	0.504	0.534	0.331	0.341	0.265	0.154	0.182

FIGURE 4-7: National Trends in Air Leakage in Houses

Year Built	Air Changes per Hour at 50 Pa, Averaged Over 10-Year Construction Period
R-2000	1.27
2001–2010	3.26
1991–2000	5.32
1981–1990	5.32
1971–1980	6.42
1961–1970	6.55
1946–1960	7.82
Pre-1946	10.73

FIGURE 4-8: Homes Evaluated and Labelled Under the EnerGuide for Houses Program

	A evaluation	B evaluation	Total
2001 – 2002	11 087	709	11 796
2000 – 2001	11 509	607	12 116
1999 – 2000	9 106	225	9 331
1998 – 1999	3 672	832	4 504

Under the EnerGuide for Houses Program, homes are evaluated to determine the potential for energy savings (an A evaluation). After renovations implementing program recommendations have taken place, some homes are revisited to determine the actual energy savings (a B evaluation).

FIGURE 4-9: Residential Energy Use and Energy Savings per Household (gigajoules per year per house)

	Energy Use Pre-Audit	Identified Energy Savings Potential	Actual Energy Savings Implemented
Average	198	48	26
2000–2002	180	77	42
1990–1999	150	34	10
1980–1989	188	33	16
1970–1979	199	49	27
1960–1969	195	46	26
1945–1959	187	46	25
Pre-1945	254	75	47

FIGURE 4-10: Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 1999 (petajoules)

	Regulated	Unregulated
Space conditioning	556.0	223.0
Water heating	296.0	0.5
Appliances and lighting	117.0	133.0
Total	**970.0**	**357.0**

FIGURE 4-13: Average Energy Consumption of New Appliances, 1990 and 2000 Models (kilowatt hours per year)

Appliance Type	1990	2000
Clothes washers	1218	838
Clothes dryers	1103	910
Refrigerators	956	640
Dishwashers	1026	637
Ranges	772	760
Freezers	714	391

FIGURE 4-15: Total Energy Savings and GHG Emissions Reductions Attributable to the EnerGuide for Equipment Program, 1990 to 2000 (GWh/kt CO_2e)

Year	Total Energy Savings (GWh)	Reduced GHG Emissions (kt CO_2e)
1990	16.4	8.9
1991	21.7	11.8
1992	40.1	21.7
1993	41.9	22.6
1994	43.2	23.4
1995	40.3	21.8
1996	43.7	23.7
1997	46.7	25.3
1998	62.4	33.8
1999	83.8	45.4
2000	91.1	49.3
Cumulative Annual	**531.3**	**287.8**

FIGURE 5-1: Commercial and Institutional Energy Use by Building Type, 2000

Building Type	Energy Use (PJ)	Percent
Retail	257.37	24.43
Office	259.23	24.65
School	146.46	13.93
Health	123.72	11.77
Hotel and restaurant	91.70	8.72
Recreation	64.12	6.10
Warehouse	52.12	4.96
Other institutional	44.65	4.25
Religious	12.12	1.15
Total	**1051.50**	

FIGURE 5-2: Commercial and Institutional Energy Use by Purpose, 2000

Building Type	Energy Use (PJ)	Percent
Space heating	536.00	50.97
Lighting	152.91	14.54
Auxiliary motor	126.65	12.04
Water heating	107.23	10.20
Auxiliary equipment	80.86	7.69
Space cooling	47.85	4.55
Total	**1051.50** (excluding street lighting, 7.35 PJ)	

FIGURE 5-3: Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.14	1.15	1.09	1.13	1.23
Energy use without efficiency improvement	1.00	1.05	1.06	1.10	1.10	1.12	1.14	1.14	1.11	1.17	1.25

FIGURE 5-4: Energy Use in Commercial Buildings, 1999 (megajoules per m^2 per year)

C-2000 projects	553
CBIP target	829
Model National Energy Code for Buildings	1105
New buildings*,**	1328
All buildings**	1585

* 1990 – 1999

** Source: Commercial and Institutional Building Energy Use Survey, 2000. Estimates relate only to the surveyed area of populations over 175 000 and in Atlantic Canada populations of over 50 000.

FIGURE 5-5: Market Penetration of Energy Innovators Initiative in Commercial and Institutional Sectors

Year	Market Share (%)	Percentage Change*
2001 – 2002	33.5	30.86
2000 – 2001	29.9	16.80
1999 – 2000	28.4	10.94
1998 – 1999	25.6	

* Percentage change as compared with base year of 1998 – 1999

Note: The percentage recruitment (i.e., sector penetration) is based on floor space and not energy bills.

FIGURE 5-6: Average GHG Reductions by Institution Under CBIP, 2002

Building Type	Average GHG Savings (tonnes/year)
Office	203.17
Health	164.39
MURB	147.80
Education	130.86
Retail	116.33
Other	62.09

FIGURE 5-7: Estimated Energy Savings from Motor Regulations, 2000 to 2020 (petajoules per year)

	2000	2005	2010	2020
Industrial energy savings	2.2	5.9	9.5	11.0
Commercial energy savings	2.1	4.6	6.8	6.7

FIGURE 6-1: Industrial Energy Use by Subsector, 2000

Industry Subsector	Percent of Industrial Energy Use
Forestry	0.5
Construction	1.6
Cement	2.1
Smelting and refining	7.1
Chemicals	7.5
Iron and steel	8.0
Petroleum refining	9.3
Mining	15.3
Other manufacturing	18.7
Pulp and paper	30.0

FIGURE 6-2: Cost of Energy to Industry as a Percentage of Total Production Cost, 1998

Industry Subsector	Energy Cost/ Total Production Cost
Transportation equipment manufacturing	0.70
Petroleum refining	2.19
Pulp and paper and wood industries	7.27
Iron and steel	9.68
Chemicals	9.94
Aluminum	17.83
Cement industry	35.21

FIGURE 6-3: Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.98	0.99	1.00	1.06	1.08	1.11	1.11	1.09	1.12	1.16
Energy use without efficiency improvement	1.00	0.98	1.00	1.02	1.08	1.11	1.12	1.15	1.15	1.20	1.25

FIGURE 6-4: Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 2000

Industry	Percent Reduction in Intensity
Pulp	-5.91
Plastic and synthetic resin	2.49
Motor vehicle	6.67
Iron and steel	8.65
Cement	9.51
Construction	9.97
Aluminum	14.29
Meat and poultry	15.27
Plastic	16.74
Petroleum refining	20.26
Brewery	20.27
Organic chemicals	23.32
Furniture and fixtures	29.46
Motor vehicle parts and accessories	39.11
Beverage	41.21
Gold mines	47.14
Glass	50.90
Electric and electronic	75.90

FIGURE 6-5: Industrial Energy Innovators and Action Plans, 1995–1996 to 2001–2002

	Number of Innovators	Number of Action Plans and Progress Reports
2001–2002	24	126
2000–2001	53	93
1999–2000	14	75
1998–1999	6	99
1997–1998	5	56
1996–1997	27	151
1995–1996	173	24

FIGURE 6-6: Participation in CIPEC Program – Participation Level in Program Elements and Consequences to Energy Consumption

	Percent of CIPEC Participants
Heads Up CIPEC newsletter	59
CIPEC Web site	45
"Dollars to $ense" workshops	42
Boiler and Heater Guide	25
Motor Systems Assessment	25
Sector Energy Efficiency Guide	25
Employee Awareness kit	23
Sector benchmarking studies	20
CIPEC Task Force meetings	18
Energy Sector Days	10

	Mean 5-Year Increases in Energy Consumption, percentage
Participants	2.20
Energy Sector Days	5.20

FIGURE 7-1: Transportation Energy Use by Mode, 2000
(petajoules per year)

Passenger light vehicle	979.08
Freight truck	710.98
Passenger aviation	239.46
Freight marine	113.99
Freight rail	80.55
Passenger bus	73.19
Off-road	82.30
Passenger rail	2.53
Total	**2282.08**

FIGURE 7-2: Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2000 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22
Energy use without efficiency improvement	1.00	0.97	1.00	1.03	1.10	1.13	1.16	1.21	1.25	1.30	1.32

FIGURE 7-3: Market Shares of New Light Trucks and Passenger Cars, 1990 to 2000 (model year) (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Light truck	30.47	30.17	30.34	33.08	34.81	35.69	39.19	42.63	43.18	41.51	40.77
Passenger car	69.53	69.83	69.66	66.92	65.19	64.31	60.81	57.37	56.82	58.49	59.23

FIGURE 7-4: New Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 1999 (index: 1990 = 1.00)

	L/100 km	L/100 km/kg	L/100 km/hp
1990	1.000	1.000	1.000
1991	0.976	0.972	0.955
1992	0.988	0.989	0.924
1993	0.988	0.985	0.915
1994	1.000	0.956	0.901
1995	0.963	0.897	0.824
1996	0.963	0.914	0.807
1997	0.976	0.920	0.809
1998	0.976	0.928	0.798
1999	0.976	0.897	0.773

FIGURE 7-5: Company Average Fuel Consumption (CAFC) vs. Canadian Voluntary Standards (litres/100 km)

Model Year	Truck Standard (11.4 L/100 km)	Trucks CAFC	Car Standard (8.6 L/100 km)	Cars CAFC
1990	11.8	11.4	8.2	8.6
1991	11.6	11.1	8.0	8.6
1992	11.6	11.3	8.1	8.6
1993	11.5	11.1	8.1	8.6
1994	11.5	11.5	8.2	8.6
1995	11.4	11.5	7.9	8.6
1996	11.4	11.3	7.9	8.6
1997	11.4	11.3	8.0	8.6
1998	11.4	11.4	7.9	8.6
1999	11.4	11.3	7.9	8.6
2000	11.4	11.1	7.7	8.6
2001	11.4	11.1	7.9	8.6
2002	11.4	11.1	7.9	8.6

FIGURE 7-6: Vehicle Fuel Efficiency Awareness

Indicator	1998	1999	2001	2002
Awareness of the Auto$mart program (general public)	9%			16%
Recollection of information on how to reduce vehicle fuel consumption (general public)	30%			36%
Percentage of new vehicles in showroom with EnerGuide label		47%	56%	
Percentage of new vehicles in lot with EnerGuide label		64%	77%	

FIGURE 8-1: Canadian Wind Power Capacity, 1990 to 2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Megawatts	4.5	4.5	4.5	0.5	21.0	21.6	21.8	25.3	50.0	75.0	125.0

FIGURE 9-1: GHG Emissions Reductions from All Federal Operations

	1990	1998	2000	2010
Emissions (kt CO_2 equivalent)	3847	3102	3031	2671

FIGURE 9-2: FBI Investment and Energy Savings

	Investment as of March 2002, \$000 000	Estimated Annual Energy Savings, Terajoules per Year
National Defence	104.8	11.80
Public Works and Government Services Canada	42.6	6.90
Other departments	20.1	3.29
Industry Canada	15.5	2.84
Natural Resources Canada	9.2	1.00
Environment Canada	8.7	1.10

FIGURE 9-3: Energy Savings from FIBP, 1991–1992 to 2001–2002
(terajoules per year)

	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002
Annual increment	20	50	40	70	90	80	77	77	93	103	112
Annual total savings	20	70	110	180	270	350	427	504	597	700	812

FIGURE 9-4: Federal Fleet Size and Fuel Consumption, 1995–1996 to 1999–2000
(litres of gasoline equivalent [thousands])

	1995–1996	1997–1998	1999–2000
Total fuel consumption (Litres of gasoline equivalent)	88 725	75 684	78 281
Vehicles	24 854	22 796	22 462

FIGURE 9-5: Purchase of ATF Vehicles for the Federal Fleet
(vehicles purchased)

	Annual	Cumulative
1997–1998	135	135
1998–1999	159	294
1999–2000	179	473

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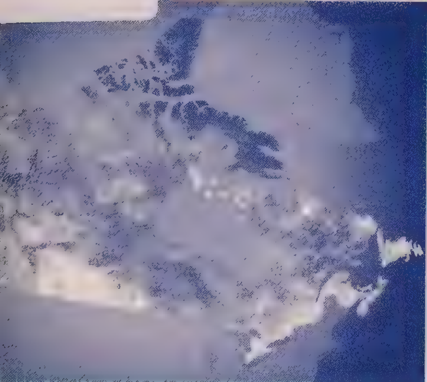

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act*

2002–2003

CANADA'S **NATURAL RESOURCES**
NOW AND FOR THE **FUTURE**

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This digital mosaic of Canada, produced by Natural Resources Canada (Canada Centre for Remote Sensing), is a composite of individual satellite images. The differences in the density of vegetation are illustrated through shading.

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Her Excellency the Right Honourable Adrienne Clarkson,
C.C., C.M.M., C.D.
Governor General of Canada and Commander-in-Chief

Your Excellency,

I have the honour to present the *Report to Parliament Under the* Energy Efficiency Act for the fiscal year ending March 31, 2003, in accordance with Section 36 of the Act.

Respectfully submitted,

R. John Efford

The Honourable R. John Efford, P.C., M.P.
Minister of Natural Resources Canada

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Minister's Foreword

This tenth report under the *Energy Efficiency Act* describes what the Government of Canada, through Natural Resources Canada (NRCan), accomplished in 2002–2003 to advance our country's energy efficiency and use of renewable energy.

The Government of Canada continues in its work to improve energy efficiency. Specifically, for a number of years, NRCan has been helping governments, industry and individual Canadians reduce energy use and save money through voluntary initiatives, programs and regulations. NRCan also supports innovative research and development, leading to new technologies that have made Canada a world leader in energy efficiency and renewable energy.

Reducing greenhouse gas (GHG) emissions is essential to addressing the global challenge of climate change. We all need to take action — governments at all levels, companies of all sizes and individuals. That is why we are encouraging all Canadians to take the One-Tonne Challenge and reduce personal GHG emissions by 20 percent. Making the right choices in our daily lives will bring us closer to this goal.

By promoting the responsible use of our energy resources and the sustainable development of our natural resources, NRCan supports the Government of Canada's agenda of strong social foundations, a strong economy for the 21st century and ensuring Canada's role of pride and influence in the world.

R. John Efford

The Honourable R. John Efford, P.C., M.P.

Minister of Natural Resources Canada

Executive Summary

With the ratification of the Kyoto Protocol in 2002, Canada formally committed to a specific target for reducing its greenhouse gas (GHG) emissions to address the global issue of climate change. Canada's industrialized economy, based largely on natural resources, makes decreasing GHG emissions a particular challenge.

In 2002–2003, Canadians spent almost $114 billion on energy to heat and cool homes and offices, to fuel vehicles and to operate appliances and industrial processes. Several factors contribute to Canadian energy demand: a vast geography, a northern climate with extreme seasonal variations in temperature and an economy founded on an abundance of natural resources.

Types of Energy Use

There are two general types of energy use: primary and secondary. Primary use comprises Canada's total consumption, including energy required to transform one form to another – such as coal to electricity – and to deliver energy to consumers. Secondary use comprises energy consumed for residential, agricultural, commercial/institutional, industrial and transportation purposes.

Between 1990 and 2001, the latest year for which figures are available, primary energy use increased by 16.5 percent, from 9714 to 11 316 petajoules (1 petajoule = 10^{15} joules). This increase, however, would have been much greater if not for the efficiency improvements made to buildings and equipment and the changes in the behaviour of energy users during the past several decades.

In 2001, secondary use accounted for 70.2 percent of primary energy use and produced 65.7 percent (473 megatonnes) of Canada's total GHG emissions. This last figure includes emissions produced by utilities in meeting the demand for electricity.

The industrial sector consumes the most energy, accounting for 38.5 percent of total secondary energy use in 2001. Transportation is second (28.6 percent), followed by residential (16.8 percent), commercial/institutional (13.3 percent) and agriculture (2.7 percent).

Four key factors contribute to changes in energy use:

- Activity – variations in levels of activity within sectors;
- Structure – shifts toward more or less energy-intensive activities;
- Weather – annual fluctuations; and
- Energy efficiency – changes in the level of energy consumption of products and equipment.

Promoting Energy Efficiency

For the past decade, Natural Resources Canada (NRCan) has promoted energy efficiency and the use of alternative energy as means to reduce GHG emissions and save money. NRCan exercises a broad range of policy instruments, including leadership, information, voluntary actions, financial incentives, research and development (R&D) and regulation.

Evidence of Change

As explained in this report, recent growth in energy use is primarily due to increased activity in various sectors. This growth, however, would have been far greater without improvements in energy efficiency. As reported in Chapter 2, energy efficiency improvements between 1990 and 2001 reduced GHG emissions by more than 44 megatonnes and decreased energy expenditures by $10.7 billion in 2001 alone.

During this period, the residential sector recorded an 18.7 percent increase in energy efficiency. The figures for transportation (10.2 percent), industry (7.8 percent) and the commercial/institutional (3.6 percent) sectors demonstrate that energy efficiency improvements are being made throughout the economy.

NRCan's efficiency and alternative energy (EAE) initiatives strive to improve energy efficiency by

- increasing the energy efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to choose buildings, equipment, systems and vehicles that are more energy efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way possible;

- influencing the energy-use practices of individuals and organizations; and
- developing technologies that provide consumers, industry and communities with new opportunities to improve energy efficiency.

NRCan's EAE initiatives strive to increase the use of alternative energy by

- encouraging investment in renewable energy systems and purchases of electricity generated from renewable sources;
- encouraging the expansion of the infrastructure for the sale of alternative transportation fuels;
- supporting R&D to reduce the costs, improve the performance and increase the scope of renewable energy technologies; and
- supporting R&D to develop safety and performance standards for renewable energy technologies.

Through improvements in energy efficiency, Canadians can reduce the size of their energy bills and achieve important environmental goals. In the short term, changes to less GHG-intensive fuels (e.g. from coal to natural gas) can help reduce GHG emissions. Over the long term, however, reducing GHG emissions to 1990 levels will require more widespread use of alternative energy.

In recent years, the production of energy derived from alternative sources has increased significantly. Between 1990 and 2001, the amount of electricity generated from the sun, the wind and biomass increased by 203 percent.

Measuring Progress

The goal of EAE initiatives is to improve energy use by altering energy-consumption practices and patterns in Canada. Measuring the effectiveness of the initiatives is of paramount importance to the success and viability of EAE.

NRCan regularly measures three aspects of EAE programs. **Program outputs** are items produced on a regular basis, such as marketing and informational materials, demonstration projects, financial incentives and regulations. These items are designed to deliver **program outcomes**, such as changes in behaviour. These alterations lead to **market outcomes**, such as observable differences in the amount and type of energy consumed.

Engaging Canadians

To maximize the effectiveness of its initiatives, NRCan engages a growing number of partners from the private and public sectors. Dozens of cooperative agreements are in place with a broad range of businesses, community groups and other levels of government.

These initiatives engage Canadian society, along with every sector of the economy, in new and more efficient approaches to secondary energy use and in the development and deployment of renewable energy sources.

This report provides an overview of the work being done in each sector, highlights NRCan's EAE programs and lists their key achievements for 2002–2003. All programs are described in the corresponding sector chapter. Program entries for market transformation programs also include quantitative performance indicators in graph or table format. A list of NRCan's EAE initiatives and expenditures appears in Appendix 1.

Housing

The residential sector accounts for 16.8 percent of total secondary energy use and 15.7 percent of Canada's annual GHG emissions. Between 1990 and 2001, residential energy use increased by 3.7 percent, while GHG emissions increased by 6.8 percent. The growth in energy use was largely due to increased activity; the relatively greater rise in GHG emissions was principally due to an increase in the carbon intensity of generated electricity.

Improvements in energy efficiency, through superior construction of new homes and reduced energy use by occupants, moderated that increase. Without these improvements, which were supported by NRCan programs, total residential energy consumption would have been 18.7 percent higher.

NRCan programs in the housing sector focus on three areas: new houses, existing houses and residential equipment, including energy-performance regulations and labelling. The majority of dwellings in Canada are detached and semi-detached houses, so most NRCan programs in this sector focus on these types of homes.

New Houses

Houses built in Canada today are more energy efficient than ever. A house constructed in 2002 consumes

33 percent less energy than a house built in 1970. Air-leakage rates have also improved dramatically. Data recorded during audits performed under EnerGuide for Houses (EGH) demonstrate that the average number of air changes per hour for homes built between 1985 and 1987 was 5.3; the number for homes built between 2000 and 2002 was 3.5.

NRCan's R-2000 Standard encourages the construction and purchase of new houses that consume less energy, produce fewer pollutants and are healthier to live in than standard houses. A house built to the R-2000 Standard undergoes only 1.1 air changes per hour and consumes 64 percent less energy than the average house constructed in 1970. During 2002–2003, a revised R-2000 standard was introduced. All previously trained professionals updated their skills, and eight new builders were trained to the new standard.

NRCan's Super E™ program supports the export of energy-efficient and environmentally friendly housing technology to foreign builders. Thanks to this program, the R-2000 concept has been adapted to several international markets. Last year marked the opening of the first Super E™ home in Scotland. Since the program began in 1978, 70 houses have been built in Japan, and 20 houses have been completed in the United Kingdom. Contracts are already confirmed for another 60 houses in the United Kingdom. Also, new Super E™ projects in Ireland and China will begin next year.

Existing Houses

NRCan programs for existing houses encourage Canadians to improve the energy efficiency of their homes. EGH provides homeowners with expert advice on how to improve the energy performance of their homes, particularly when undertaking renovation and maintenance projects. Homeowners who completed retrofit activities experienced an average annual energy savings of 19 percent.

In 2002–2003, more than 17 000 houses underwent energy evaluations through EGH. The overall client-satisfaction rate with EGH services was above 90 percent; 76 percent of EGH clients described the service as "exceeding expectations."

On average, houses built before 1946 and evaluated under EGH had potential energy savings of 111 gigajoules per year – meaning homeowners could reduce their energy use by nearly 40 percent. For those who implemented some of the suggested modifications, the actual average energy savings were closer to 23 percent.

Residential Equipment

NRCan develops regulations and sets standards for the energy performance of residential equipment, such as appliances and furnaces. The regulations now cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial/institutional sector.

Through labelling and promotional activities, NRCan also encourages the manufacture and purchase of more energy-efficient equipment.

Between 1990 and 2001, the energy efficiency of new household appliances increased substantially. An average 2001-model freezer, for instance, consumes 46 percent less energy than a similar 1990 model. The 2001-model refrigerators and dishwashers consume, on average, 42 percent and 38 percent less energy, respectively.

From 1990 to 2000, the EnerGuide labelling program is estimated to have resulted in a total energy savings of 531 gigawatt hours and a reduction of 287 kilotonnes of GHG emissions.

Buildings

Retail and office space accounts for more than half of the building sector's energy demands. Schools, health-care facilities, hotels and restaurants account for a further 26 percent.

Between 1990 and 2000, commercial and institutional energy use increased by 21.5 percent. In 2001, the commercial/institutional sector accounted for 13.3 percent of total secondary energy use and 13.0 percent of GHG emissions. However, improvements in energy efficiency worked to decrease total energy use by 3.6 percent.

NRCan programs address all building types with measures that target new buildings, existing buildings and equipment.

New Buildings

NRCan provides financial incentives to builders and developers who incorporate energy-efficient features into new construction projects. During 2002–2003,

79 contributions worth a total of $3.9 million were made to construction projects involving commercial, institutional and multi-unit residential buildings. The energy efficiency of these buildings increased by an average of 34.4 percent.

NRCan also provides assistance to builders and developers of industrial structures. In 2002–2003, nine contribution agreements were signed. Moreover, 28 architects and engineers received training on energy-efficient industrial building design.

Existing Buildings

NRCan provides businesses and institutions with access to tools and financial assistance to improve the energy efficiency of their existing buildings. More than 700 organizations have made formal commitments to reduce GHG emissions and improve energy efficiency.

Between 2001 and 2003, federal contributions to renovation and retrofitting projects totalled $12.7 million, and client investment equalled $207 million. Actual energy savings achieved through these projects was worth $33.5 million.

Equipment

Through a range of equipment programs, NRCan establishes standards and regulations for energy efficiency and supports the development, testing, deployment and promotion of new technologies.

In 2002–2003, NRCan increased the minimum-performance standards for ballasts and room air conditioners and established new standards for dry-type transformers and incandescent reflector lamps. Products that consume 50 percent of the energy used in the commercial/institutional sector must now meet standards for energy efficiency.

NRCan also develops and distributes building-simulation software tools to support advancements in building technology. Architects and engineers use these tools to optimize energy performance. To date, the software has been used to simulate the energy performance of more than 45 000 houses for NRCan's R-2000 and EGH and more than 800 buildings for the Commercial Building Incentive Program.

NRCan collaborates with associations, governments and businesses to develop specialized solutions to reduce energy consumption and GHG emissions in a cost-effective manner. In 2002–2003, NRCan attracted more than 80 participants from across Canada to a national workshop on supermarket refrigeration systems. NRCan also started an innovative demonstration project that integrates supermarket refrigeration, heating and ventilation systems to save energy.

Industry

The industrial sector – forestry, construction, mining and manufacturing – accounts for 38.5 percent of secondary energy use and 33.6 percent of GHG emissions.

Between 1995 and 2001, industrial energy use rose by 3 percent in Canada, while GHG emissions grew by 10.6 percent. However, during the same period, industrial activity increased by 22.4 percent. Improvements in energy efficiency helped reduce total energy use by 8 percent.

Within this sector, NRCan's energy efficiency initiatives focus on industrial processes and technologies, and equipment.

Industrial Processes and Technologies

NRCan works with companies and associations to encourage and support efforts to invest in, develop and employ more energy-efficient methods and to reduce GHG emissions. During 2002–2003, the number of registrants to the Industrial Energy Innovators program grew to 77 from 24 the year before.

At the sector level, organizations that participated in NRCan's Canadian Industry Program for Energy Conservation (CIPEC) realized significant savings. The mean five-year increase in energy consumption was 2.2 percent for CIPEC participants and 5.2 for non-participants.

NRCan also helps industry develop cleaner, more energy-efficient combustion processes. Current research focuses on optimizing the performance of stationary combustion equipment and developing and evaluating new products, fuels and retrofit activities.

In 2002–2003, NRCan tested and optimized a Canadian technology to remove sulphuric- and nitric-oxide pollutants from the flue gases of coal-fired boilers, producing fertilizer as a by-product.

NRCan helped finance a pilot installation at a coal-fired power plant in Ontario that could reduce emissions of

nitrogen oxides by up to 35 percent. The process, known as Fuel Lean Gas Reburn™, relies on natural gas to improve combustion.

Equipment

Through regulation, standards setting, labelling and research support, NRCan programs work to improve the energy efficiency of equipment used in industry.

Canada's *Energy Efficiency Regulations* set out minimum performance standards through the *Energy Efficiency Act* to eliminate the less energy-efficient models of energy-using equipment from the market. EnerGuide for Equipment promotes and encourages the manufacture, purchase and use of more energy-efficient industrial equipment.

Transportation

The transportation sector accounts for more than 28.0 percent of secondary energy use and 34.4 percent of GHG emissions. This sector is divided into three sub-sectors: passenger, which comprised 57.8 percent of total energy use in 2001; freight, 38.5 percent; and off-road, 3.6 percent.

Between 1990 and 2001, transportation energy use grew by 21.3 percent. Two main factors were responsible for the rise: an increase in activity and a shift toward larger vehicles. While the fuel efficiency of new vehicles has improved markedly, average fuel economy has been stable, because new cars and trucks are increasingly heavier and feature more powerful engines.

Between 1990 and 2001, improvements in energy efficiency reduced energy use in this sector by 10.2 percent from what it would have been in the absence of such improvements.

In 2001, road transport, at 77.8 percent, was the largest user of energy in the sector. Passenger energy use accounted for 48 percent of that total, and freight, 30 percent. In this sector, NRCan focuses its energy-use programs on road transportation, dividing them into four areas: personal vehicles, fleet vehicles, R&D and alternative fuels.

Personal Vehicles

NRCan programs encourage manufacturers to meet standards for fuel consumption and to improve fuel efficiency by adopting advances in technology. NRCan also encourages private motorists to purchase energy-efficient vehicles. Under a voluntary agreement, manufacturers attach EnerGuide fuel-consumption labels to their cars so that purchasers can make informed buying decisions.

The Auto$mart Student Driving Kit helps instructors teach fuel-efficient driving techniques to novice drivers. During 2002–2003, 150 new instructors were recruited into the program. As of March 2003, more than 800 000 novice drivers had been exposed to these fuel-efficiency techniques.

Fleet Vehicles

In partnership with fleet and industry associations and other levels of government, NRCan delivers information materials, workshops, demonstrations and training to fleet operators to help improve fuel efficiency and encourage the use of alternative fuels in commercial and municipal fleets.

During 2002–2003, the SmartDriver Initiative trained more than 149 000 novice and experienced drivers in fuel-efficient driving techniques. To date, the Fleet Vehicles initiative has registered more than 2800 members, representing more than 400 000 fleet vehicles.

Transportation Technology Research and Development

NRCan supports research into transportation technologies that improve the energy efficiency of vehicles and reduce GHG emissions.

During 2002–2003, a pilot process was developed that could lead to greater use of lightweight materials in vehicle manufacturing and increased fuel efficiency. The process involves seam-welding aluminum tubes for hydroforming.

In the mining industry, NRCan plays a lead role in a consortium that is developing a mining vehicle powered by fuel cells. A test vehicle underwent extensive surface testing during 2002–2003.

Alternative Transportation Fuels

NRCan promotes the use and development of alternative fuels, such as ethanol, natural gas and fuel cells, to minimize environmental impacts.

During 2002–2003, two provinces announced plans to introduce legislation requiring ethanol in government vehicles. Additionally, the first public E-85 (85 percent ethanol) fuelling station opened in Canada.

Renewable Energy

Renewable energy includes the well-established hydroelectric industry, which generates about 60 percent of all electricity in Canada. Small-scale projects, defined as those with a capacity of 20 or fewer megawatts, now provide about 4 percent of Canada's total capacity and offer excellent potential for increased production.

Several other renewable energy sources and technologies, such as wind power, also hold much promise. National wind power capacity has increased substantially in recent years, reaching 230 megawatts in 2002 with SaskPower's construction of a second wind farm.

NRCan delivers several initiatives to encourage the development and use of renewable energy. These initiatives support education and promotion programs, develop standards and research, and provide financial incentives for capacity building.

Renewable Energy Programs

During 2002–2003, the Government of Canada purchased more than 45 gigawatt hours of electricity from renewable source projects in Saskatchewan and Prince Edward Island. This resulted in a 40-kilotonne reduction of GHG emissions. The governments of Alberta and Ontario have also committed to purchasing electricity from renewable sources.

More than $900,000 in federal incentives were distributed to 50 projects under the Renewable Energy Deployment Initiative. Valued at $5 million, these projects have led to an annual reduction of approximately 5.8 megatonnes of GHG emissions.

In 2002–2003, the Renewable Energy Capacity-Building Program developed a new Web site that offers software to help decision-makers analyse the feasibility of renewable energy projects. Software that features a baseline model is under development.

Canada's first solar-powered car wash opened in Markham, Ontario, thanks to a partnership with Suncor Energy Products Inc.

NRCan's Wind Power Production Incentive (WPPI) aims to support the installation of 1000 megawatts of new wind energy capacity by 2007. By displacing other sources, wind power capacity installed under the WPPI is projected to reduce annual GHG emissions by three megatonnes by 2010. In 2002–2003, five projects were completed or under construction, for a total new capacity of approximately 93 megawatts.

Federal House in Order

As the country's largest single enterprise, the Government of Canada is getting its own energy-use house in order. The government has established a target of a 31 percent reduction in GHG emissions by 2010.

The Government of Canada has already achieved a 24 percent reduction since 1990 through a series of measures, including building retrofits, improvements in fleet management, downsizing of operations and purchases of green power. In 1990, emissions were 3837 kilotonnes; in 2001, emissions were down to 2987 kilotonnes. The Government of Canada plans a further reduction of 12 percent by 2010.

Key departments and agencies that are responsible for 95 percent of federal GHG emissions have been assigned specific targets under a three-year action plan and must report annually on their programs. NRCan provides services and support to federal departments and agencies to help them achieve their energy efficiency targets.

Federal Initiatives

The Federal House in Order initiative includes such activities as GHG inventory and tracking, purchases of green power (emerging sources of renewable electricity) and efforts to reduce outside emissions.

Under the Federal Buildings Initiative, NRCan helps organizations implement energy efficiency improvements through private-public partnerships. During 2002–2003, about $1 million worth of incremental energy savings were achieved through this program. In addition, energy intensity improved by 20 percent and GHG emissions were reduced by 15 to 20 percent.

The Federal Industrial Boiler Program (FIBP) provides technical and project-management services to federal departments and agencies that are implementing energy efficiency projects. Since its inception in 1991, the FIBP has worked with Agriculture and Agri-Food Canada, the Department of National Defence, Environment Canada and the Department of Foreign Affairs and International Trade, among others. These partnerships have reduced GHG emissions by an average of 4.7 kilotonnes per year.

Through the Federal Vehicles Initiative, NRCan helps other departments and agencies improve the efficiency of their fleets and switch to cleaner-burning fuels. During 2002–2003, the number of federal vehicles using E-85 fuel, (85 percent ethanol) doubled to more than 200. In addition, the federal fleet now includes more than 130 hybrid gasoline-electric vehicles. Another promising trend is the continued rise in the percentage of newly acquired vehicles that can operate on alternative fuels: from 3 percent of the federal fleet in 2001–2002 to more than 10 percent in 2002–2003.

Introduction

Greenhouse Gases and Climate Change

Climate change is a global challenge arising from the continuing buildup in levels of anthropogenic (human-produced) greenhouse gases (GHGs) in the atmosphere, in addition to naturally occurring emissions. GHGs are constituted by a number of gases, but the main source of anthropogenic emissions is carbon dioxide (CO_2) from the combustion of fossil fuels. Substantially reducing GHG emissions is a challenge, particularly given Canada's highly industrialized and resource-based economy. Solutions require a multifaceted, coordinated domestic response and a high level of cooperation among all nations.

In December 1997, Canada and more than 160 other countries met in Kyoto, Japan, and agreed to targets to reduce GHG emissions. Canada's target is to reduce its GHG emissions to 6 percent below 1990 levels by the first commitment period (2008 to 2012). After signing the Kyoto Protocol, Canada established a National Climate Change process with provinces, territories, stakeholders and the Canadian public to examine the potential impacts, costs and benefits of the protocol and possible options for its implementation.

The Government of Canada ratified the Kyoto Protocol and notified the United Nations of its decision on December 17, 2002. Earlier, in November 2002, the Government of Canada had released the Climate Change Plan for Canada, which provides a framework for the way forward on climate change, while allowing for continuous adjustment. It also proposed a further range of initiatives for reducing GHG emissions.

Natural Resources Canada's Efficiency and Alternative Energy Program

Over the past decade, Natural Resources Canada (NRCan) has emphasized the promotion of energy efficiency and the use of alternative energy (i.e. alternative transportation fuels and renewable energy) as a means to reduce GHG emissions, particularly in relation to the Kyoto Protocol. A complete listing of NRCan's energy efficiency and alternative energy (EAE) initiatives in 2002–2003 is provided in Appendix 1. These initiatives engage Canadian society and all major sectors of the economy in new and more advanced approaches to secondary energy use – i.e. the consumption of energy in the residential, commercial and institutional, industrial and transportation sectors.

NRCan's EAE initiatives are managed by

- the Office of Energy Efficiency (OEE), which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels;
- the CANMET Energy Technology Centre and the Mineral Technology Branch, which deliver EAE research and development (R&D) initiatives;
- the Electricity Resources Branch, which delivers market transformation initiatives for renewable energy; and
- the Science Branch of the Canadian Forest Service, which undertakes R&D in the use of forest biomass for energy.

[1] CANMET is the Canada Centre for Mineral and Energy Technology.

In its efforts to reduce GHG emissions, NRCan emphasizes partnership and cooperation with stakeholders, such as other levels of government, the private sector and non-governmental organizations. Using this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side, Canada participates in developing technology for tapping renewable energy resources and alternative transportation fuels as well as increasing the energy efficiency of production.

In This Report

This tenth annual Report to Parliament focuses principally on EAE initiatives that address secondary energy use. Chapter 1 provides the policy context and strategic overview. Trends in energy use and GHG emissions in Canada are discussed in Chapter 2. Chapter 3 summarizes work undertaken during the reporting period to improve the quality and coverage of performance indicators for the initiatives described in Chapters 4 through 9. Chapters 4 to 7 review individual EAE initiatives to improve energy use in housing, buildings, industry and transportation, highlighting their achievements and progress indicators. Chapter 8 deals with renewable energy sources and use. Chapter 9 describes the Government of Canada's actions to improve its own use of energy. The final chapter describes intergovernmental cooperation in EAE.

Chapter 1: Policy Context and Legislation

Federal Policy and Measures on Energy Efficiency and Alternative Energy

Energy use has been a policy concern since the 1970s when governments responded to the oil crises of 1973 and 1979 by promoting energy conservation and renewable energy sources. By the mid-1980s, world oil supply had become sufficiently abundant that governments deregulated energy prices and markets and phased out most energy conservation and renewable energy programs.

Toward the end of the 1980s, individuals, organizations and governments around the world became concerned that greenhouse gas (GHG) emissions produced by burning fossil fuels – such as coal, oil and natural gas – could contribute to climate change. In 1990, Canada's concern about its GHG emissions (which result mostly from energy use) spurred an expansion of the federal program to improve energy efficiency and increase the use of alternative energy sources. These measures encouraged investment in corporate and consumer energy efficiency and alternative energy (EAE) opportunities and sought the engagement of all sectors of the economy and Canadian society in rethinking and improving energy use. Since 1991, a number of major developments have affected Natural Resources Canada's (NRCan's) EAE policies and programs.

In 1992, Canada signed and ratified the *United Nations Framework Convention on Climate Change* (UNFCCC). Under this convention, Canada and other countries agreed to work to stabilize GHG emissions at 1990 levels by 2000. In 1995, federal and provincial ministers of energy and the environment approved the National Action Program on Climate Change, which included as a key strategic element the promotion of energy efficiency in all sectors of the economy. At the same time, they established the Climate Change Voluntary Challenge and Registry (VCR). Later, in October 1997, it was incorporated as a non-governmental, not-for-profit organization. Canada's Climate Change Voluntary Challenge and Registry Inc. (VCR Inc.) invites Canadian companies and organizations to develop action plans to limit their net GHG emissions and to file these, as well as progress reports and achievements, on its public registry.

The federal budget of February 1997 provided $60 million over three years for new initiatives to improve energy efficiency in new commercial buildings; encourage commercial building retrofits; provide for energy performance assessments of houses; and stimulate demand for cost-effective, commercially available renewable energy systems for space and water heating and cooling. This funding was renewed in the February 2000 federal budget and further extended to March 2006 in the budget of February 2003.

In December 1997, at the third Conference of the Parties to the UN Framework Convention on Climate Change in Kyoto, Japan, the participating countries agreed to reduce GHG emissions from 1990 levels within 2008 to 2012. Canada pledged to reduce its emissions by 6 percent. The protocol will enter into force when at least 55 parties to the Framework Convention, representing 55 percent of industrialized countries' GHG emissions, have ratified it.

In February 1998, the federal budget provided $150 million over three years for a Climate Change Action Fund (CCAF) to help Canada develop its response to the Kyoto Protocol. This funding was renewed in the February 2000 federal budget. The fund had four components:

- *Public Education and Outreach* to build public awareness and understanding of climate change and encourage action to reduce GHG emissions;
- *Technology Early Action Measures* (TEAM) to share with the private sector the risk of demonstrating cost-effective technology projects that will lead to reductions in GHG emissions;
- *Science, Impacts and Adaptation* to support research to advance our knowledge of the magnitude, rate and regional distribution of the impacts of climate

change on Canada and to support the development of adaptation strategies; and

- *Foundation Analysis* to support the National Climate Change Process and the analysis of options for reducing Canada's GHG emissions.

The federal, provincial and territorial governments established the National Climate Change Process in 1998 to examine the impact, costs and benefits of the Kyoto Protocol and the implementation options open to Canada. From spring 1998 to winter 1999–2000, the process engaged more than 450 experts from across Canada, and their recommendations were provided to governments in fall 2000. In May 2002, the Government of Canada released the *Discussion Paper on Canada's Contribution to Addressing Climate Change* to continue consultations with stakeholders. NRCan officials have provided a great deal of support, analysis, advice and guidance to the National Climate Change Process.

In addition to the previously noted renewal of funding for four EAE initiatives and the CCAF, the federal 2000 budget also provided funds for the Green Municipal Enabling Fund (GMEF) and the Green Municipal Investment Fund (GMIF). The federal budget of December 2001 doubled the initial endowment. The Federation of Canadian Municipalities manages the two funds under agreements with NRCan and Environment Canada. The GMEF is a $50-million endowment, available for five years, to contribute to feasibility studies of energy and environmental projects in municipal operations. The GMIF is a permanent, $200-million endowment to provide loans and loan guarantees to eligible recipients to carry out energy and environmental projects. It also provides grants and long-term loans for pilot projects that demonstrate innovative technologies and processes.

Building on a successful initial purchase of green power in Alberta, the February 2000 federal budget expanded the pilot initiative to permit the procurement of $15 million in renewable energy over the next 10 years for federal facilities in Saskatchewan and Prince Edward Island.

In October 2000, the Government of Canada announced its *Action Plan 2000 on Climate Change*, representing its contribution to *Canada's First National Climate Change Business Plan* developed with the provinces and territories. Funding of $500 million over five years was provided in the budget update of October 2000 for a broad range of measures that commenced operation in 2001–2002.

In November 2002, the Government of Canada released the *Climate Change Plan for Canada*, outlining how Canada can meet its GHG reduction target. The Plan sets out a three-step approach: the first step is the measures implemented under Action Plan 2000; the second, a set of new initiatives; and the third, options for attaining the target by the end of the first commitment period in 2012. The federal budget of February 2003 provided new funding of $2 billion over five years commencing with fiscal year 2003–2004 to support the climate change initiatives identified in the Plan. This is in addition to the $1.7 billion in climate change investments announced by the Government of Canada since 1997. The next edition of this Report to Parliament will describe the measures implemented with this new funding.

Responsibility

In April 1998, NRCan's Office of Energy Efficiency (OEE) was established, with a mandate to strengthen and expand Canada's commitment to energy efficiency, in particular to help address the challenges of climate change. The OEE's initiatives target all final energy consumers and emphasize partnerships and economic investment. Its program objectives are to overcome the market barriers posed by inadequate information and knowledge about energy efficiency and alternative transportation fuels, and to address institutional deterrents in energy-use markets and economic constraints that energy users face. The OEE is also responsible for identifying opportunities for new and heightened energy efficiency measures. The National Advisory Council on Energy Efficiency assists the OEE by providing advice and guidance. The council comprises energy efficiency experts and leaders from all sectors of the economy.

NRCan's Office of Energy Research and Development (OERD) coordinates and funds non-nuclear, energy-related research and development (R&D) for the Government of Canada in partnership with 12 federal departments and agencies through the Program of Energy Research and Development (PERD). Seventy-seven percent of PERD's current programs contribute to finding technology solutions to help

Canada address its climate change challenges. PERD promotes the development of energy-efficient, renewable and alternative energy sources and technologies and the development and use of Canada's oil and gas resources in a clean and safe manner.

NRCan's CANMET Energy Technology Centre (CETC) focuses on technology development and deployment. Technology development activities are performed on a cost-shared basis either through in-house R&D work at its laboratories or by providing funding support to its technology partners. CETC – Ottawa, in Ontario, works in partnership with a range of stakeholders to develop and disseminate innovative, cleaner energy technologies. These include energy-efficient technologies for homes, businesses and industry; renewable energy; alternative transportation fuels; district heating and cooling systems; advanced low-emissions combustion technologies; and energy-efficient metallurgical fuel products and technologies. CETC – Varennes, in Quebec, develops technologies that use energy wisely and help Canadians stay competitive in the marketplace. These include advanced drying technologies, heat transfer and storage systems, photovoltaics, renewable energy for remote communities and related software tools, such as RETScreen® International.

The Electricity Resources Branch (ERB) is the fourth organization within NRCan's Energy Sector reporting on programs in this document. Within the ERB, the Renewable and Electrical Energy Division promotes the development of a sustainable renewable energy industry in Canada. It promotes investments in renewable energy systems for heating and cooling and provides information on renewable energy technologies. By strengthening markets for the renewable energy industry, its programs contribute to GHG reductions, job creation and export sales.

Outside of the Energy Sector, two other sectors within NRCan report on programs related to energy efficiency and alternative energy in this document. They are the Canadian Forest Service and the Minerals and Metals Sector.

Energy Efficiency Strategy

Most of NRCan's EAE initiatives deal solely with energy efficiency. Their goal is to improve energy efficiency by

- increasing the energy efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to purchase buildings, equipment, systems and vehicles that are more energy efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way;
- influencing the energy-use practices of individuals and organizations; and
- developing technologies to give consumers, industry and communities new opportunities to improve energy efficiency.

These measures help the demand side of the energy market move toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels.

Alternative Energy Strategy

In the short term, energy efficiency improvements can contribute significantly to energy savings and environmental objectives. In the long term, however, reducing GHG emissions will require greater use of alternative energy sources.

Alternative energy includes renewable sources other than large hydro-electric facilities, new applications of conventional sources and new fuels, such as hydrogen for fuel cells. (Large hydro is not considered an alternative energy source because it is already a successful, well-established mode of energy production, supplying more than 60 percent of the electricity in Canada.) Some technologies, such as those related to the use of propane as a vehicle fuel and to forestry biomass, are already commercially available and accepted. Some have found applications in specialized markets, such as remote communities. Others are still in the early stages of development.

Federal initiatives are helping to expand the infrastructure (e.g. fuelling stations) for the sale of alternative transportation fuels, especially in urban areas where the provision of infrastructure is more economic. R&D focuses on ways to improve options in the use of these fuels.

NRCan supports R&D to reduce costs, improve performance, develop safety and performance standards and increase the scope of renewable energy technologies. The department also provides incentives for investments in renewable energy systems and purchases of electricity generated from renewable sources, disseminates information to consumers, and assesses economic and environmental aspects of renewable sources of energy.

Policy Instruments

NRCan's key policy instruments are as follows:

- leadership;
- information;
- voluntary initiatives;
- financial incentives;
- regulation; and
- research and development.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing energy efficiency and the use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates information to consumers, using methods that range from broad distribution to individual consultations with clients, to increase awareness of the environmental impact of energy use and to encourage consumers to become more energy efficient and to make greater use of alternative energy sources. Activities include publications, exhibits, advertising, toll-free lines, conferences, Web sites, workshops, training, building-design software and promotional products.

Voluntary Initiatives

Companies and institutions work with NRCan on a voluntary basis to establish and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target large consumers of energy in the commercial, institutional and industrial sectors and organizations whose products are important determinants of energy use. The initiatives involve industry-government agreements and, for groups of large industrial energy users, energy efficiency target setting. NRCan provides a variety of support services to assist and stimulate action by companies and institutions on energy efficiency, including developing standards and training.

Financial Incentives

NRCan uses financial incentives to encourage final users of energy to employ energy efficiency and renewable energy technologies and practices when they acquire, design or build new buildings or retrofit existing ones. NRCan also offers financial incentives for wind energy and for natural gas vehicles and refuelling infrastructure.

Regulation

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations concerning EAE, primarily performance and labelling requirements for energy-using products (as well as doors and windows) that are imported or shipped from province to province. Regulation also involves working with provincial governments to improve the energy efficiency provisions in Canadian building codes.

Research and Development

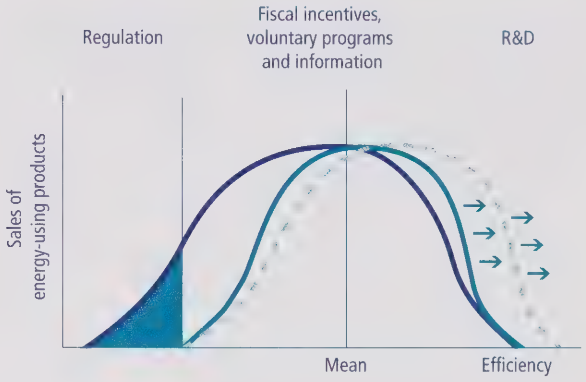
NRCan's EAE initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. R&D also provides the scientific knowledge needed to develop the technologies, codes, standards and regulations required for the sustainable use of energy.

NRCan provides national leadership in energy science and technology (S&T) by undertaking in-house research in its own laboratories, by contracting out research activities to other organizations and through the federal PERD. PERD and TEAM are the only federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

Figure 1-1 shows how these policy tools work together to increase energy efficiency, i.e. how they help to reduce the amount of energy needed to obtain a certain level of service. R&D increases the opportunities for achieving greater levels of efficiency in a particular type of energy use. Non-R&D measures increase the take-up of existing opportunities to use energy more efficiently. Regulations also eliminate less-efficient products from the market.

FIGURE 1-1

Moving the Market



Chapter 2: Trends in Energy Use

Introduction

Canadians enjoy an abundance of energy from a variety of sources. This comparative advantage in the supply of energy has helped Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. It also has favoured the development of industries that have a particularly strong energy demand. As a result, Canada consumes more energy per capita than most countries.

Canadians spend almost $114 billion per year on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes. This represents 10.4 percent of the country's gross domestic product.

Energy Use and Greenhouse Gas Emissions

There are two general types of energy use: primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (e.g. coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use is energy used by final consumers for residential, agricultural, commercial, industrial and transportation purposes.

Primary energy use in Canada today reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. Primary energy use increased by 16.5 percent between 1990 and 2001, from 9714 petajoules to 11 316 petajoules.

Secondary energy use (7949 petajoules) accounted for 70.2 percent of primary energy use in 2001. It was responsible for 65.7 percent (473 megatonnes) of total greenhouse gas (GHG) emissions in Canada, if indirect emissions – namely, those produced by electric utilities to meet end-use electrical demand – are included.

This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane and nitrous oxide. CO_2 represents the majority of Canada's GHG emissions. All subsequent references in this report to CO_2 and GHGs include emissions that are attributable directly to secondary energy use and indirect emissions attributable to electricity generation, unless otherwise specified.

From 1990 to 2001, secondary energy use increased by 13.8 percent. GHG emissions attributable to secondary energy use increased by 16.1 percent because of a 2.3 percent increase in the GHG intensity of energy users. This reflects changes in the fuel mix used to generate electricity. The GHG intensity of electricity increased by 15.3 percent over the period. The industrial sector is the largest energy user, accounting for 38.5 percent of total secondary energy use in 2001. The transportation sector is the second largest energy user at 28.6 percent, followed by the residential sector at 16.8 percent, the commercial and institutional sector at 13.3 percent and the agriculture sector at 2.7 percent.

Energy Efficiency

Natural Resources Canada (NRCan) annually publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use (and GHG emissions) and the contribution of the following key factors to these changes:

- increases in sector *activity* lead to increased energy use and emissions. In the residential sector, for example, an increase in the number of households has the effect of increasing energy use;
- a shift in the *structure* of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter;
- fluctuations in *weather* lead to changes in space-heating and cooling requirements. A colder winter or a warmer summer can lead to increased energy use; and
- *energy efficiency* – how effectively energy is being used, for example, how long an appliance can be operated with a given amount of energy.

In this report, changes in energy efficiency are the net result after allowing for the changes in energy use due to changes in activity, structure and weather. To the extent that other factors that affect energy use have not been captured, this measure of energy efficiency improvement might overstate or understate the "actual" change. For example, in the industrial sector, there may have been changes in energy use due to shifts in the mix of products, but this is not captured.

Secondary energy use increased by 13.8 percent between 1990 and 2001 (from 6988 to 7949 petajoules). Due to data limitations in the industrial sector as Statistics Canada converts to a new industrial classification system, the analysis of factors affecting energy use could not be done for 1990–2001. However, the energy savings for this period have been estimated by coupling the 1990–1995 data from the 2000 database with the 1995–2001 data from the 2001 database and re-basing them to 1990. Using this methodology, it can be estimated that if only activity, structure and weather had been in effect, secondary energy use would have increased by 24.7 percent. However, improvements in energy efficiency worked to decrease energy use by 9.6 percent (764 petajoules).

TABLE 2-1

Explanation of Changes in Secondary Energy Use, 1990 to 2001 (in petajoules) *

	Sectors						
	Residential	Commercial/ Institutional	Industrial	Transportation	Agriculture	Total	% Change
1990 energy use	1289.0	867.0	2755.0	1878.0	199.0	6988.0	
2001 energy use	1337.0	1054.0	3064.0	2277.0	218.0	7949.0	
Change in energy use	48.0	187.0	309.0	399.0	19.0	961.0	13.8
Explanatory Factor (change due to)							
Activity	280.2	218.5	n/a	344.1		n/a	
Structure	36.5	8.0	n/a	215.1		n/a	
Weather	-28.5	-7.9	n/a	n/a		-36.4	0.5
Energy efficiency	-240.7	-30.7	-311.7	-181.3		-764.4	9.6
Other factors		-1.2		21.4	18.9	39.1	0.5

*The factorization analysis results for the industrial sector for 1995–2001 are as follows:

- activity (economic growth) raised secondary energy use by 665 petajoules;
- changes in the structure of activity decreased secondary energy use by 343 petajoules; and
- energy efficiency decreased secondary energy use by 232 petajoules.

As a result, energy use increased by only 13.8 percent. This change in energy use between 1990 and 2001, with and without changes in energy efficiency, is shown in Figure 2-1. The difference in energy use due to energy efficiency – the energy saving – represents a reduction in energy costs of $10.7 billion a year and a reduction in GHG emissions of over 44 megatonnes. Changes in energy efficiency are estimated for each of the four major end-use sectors and presented in Chapters 4 to 7. The energy efficiency improvements were largest in the residential sector (18.7 percent), followed by the transportation (10.2 percent), industrial[1] (11.3 percent) and commercial and institutional (3.6 percent) sectors.[2]

Renewable Energy

As previously noted, changes in the fuel mix employed by the Canadian economy can reduce GHG intensity. Although in the near term this can be achieved by moving from more- to less-GHG-intensive fuels (e.g. from coal to natural gas), over the longer term the use of renewable energy sources is expected to accelerate this trend.

Figure 2.2 shows the trend in the use in Canada of electricity generated from wind, solar and biomass, indicating a 203 percent increase over 1991–2000. Although representing only a small component of overall electricity use, the proportion of electricity generated from these renewable energy sources increased from 0.75 percent to 1.28 percent over the period, representing a 58 percent increase in its share. Most of this production was derived from biomass.

The graph does not include hydro sources, either conventional or small (less than 20 megawatts). The former accounts for about 60 percent of electricity generated in Canada; installed capacity is over 67 gigawatts. There are over 230 small hydro installations in Canada, with a total capacity of about 1500 megawatts.

FIGURE 2-1

Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001

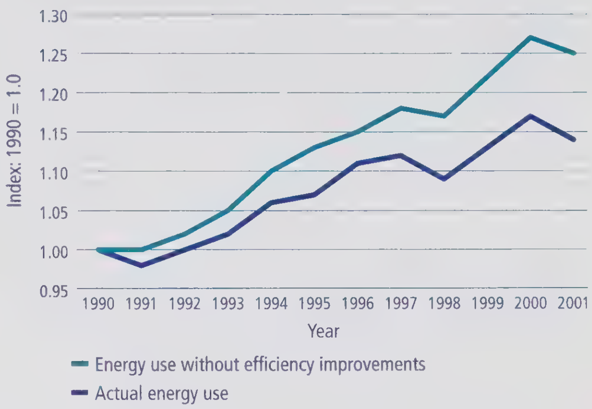
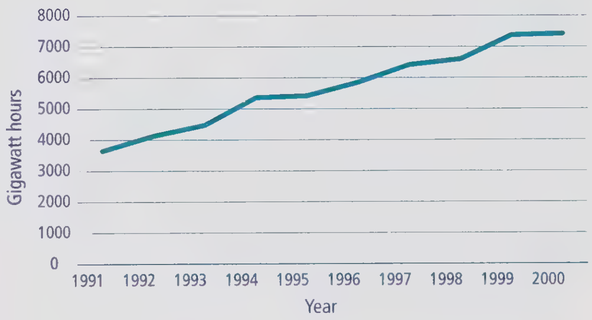


FIGURE 2-2

Electricity Production From Renewable Sources



[1] Calculated by coupling the 1990–1995 data from the 2000 database with this year's 1995–2001 data and re-basing them to 1990 in the industrial sector.

[2] The aggregate energy-use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix A of Natural Resources Canada's *End-Use Energy Data Handbook, 1990 and 1995 to 2001*.

Chapter 3: Measuring Progress

Background

The primary goal of Natural Resources Canada's (NRCan's) energy efficiency and alternative energy (EAE) initiatives is to change energy consumption patterns to obtain environmental and economic benefits. Part of assessing program progress and performance involves considering program delivery and program effectiveness.

NRCan focuses on the monitoring and tracking of the following three aspects of program delivery:

- program outputs;
- program outcomes; and
- market outcomes.

Program outputs are the items produced regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. These outputs are designed to lead to *program outcomes* – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would have purchased if there had been no program. Other important factors that influence consumer behaviour include product price, household income, personal taste and other government and non-governmental programs.

Since program outcomes can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable *market outcomes*. Market outcomes ultimately reflect the impacts of NRCan programs on changes in energy efficiency, energy intensity, greenhouse gas (GHG) emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress towards a market outcome, serves as an indicator of program effectiveness. An example of a program outcome that leads to a market outcome is a householder's purchase of a more energy-efficient appliance and reduced use of electricity. Depending on the source of electricity, and how the utility changes its electricity-generating methods to meet the change in demand that results from reduced electricity use, this could also lead to a decline in GHG emissions.

Focusing on Results

The government-wide initiative aimed at "managing for results" has encouraged management in all federal departments and agencies to focus more on the impacts of their programs and services on the lives of Canadians. Managing for results requires more than just the monitoring of program delivery; it means clearly defining the results to be achieved, increasing the emphasis on program and market outcomes, measuring and evaluating program performance, and making adjustments to improve the efficiency and effectiveness of programs. It also means reporting on performance in ways that make sense to Canadians.

Measuring program and market outcomes can be time-consuming, costly and difficult. In particular, quantifying program outcomes requires client and data surveys and detailed analyses of energy use. NRCan's National Energy Use Database (NEUD) initiative helps the department track changes in energy consumption at the end-use level. Still, it is difficult to determine the incremental effects of programs because other factors, such as variation in energy prices, also influence these effects. Moreover, because several factors and programs can influence a consumer at the same time, it is difficult to determine the separate contribution of each factor and program to the total effect. Consequently, quantifying program outcomes, impacts and, ultimately, results also requires some knowledge of attribution – or the proportion of the observed or estimated market outcome that can be reasonably attributed solely to program activities and efforts.

This report uses a mix of progress indicators, which are quantitative where possible. The challenge for NRCan is to continuously improve the coverage and quality of

these progress indicators, in general and in order to ensure that they increasingly reflect a focus on results. The following section highlights some of NRCan's more recent efforts to improve the quality of its program performance information.

Highlights of the Office of Energy Efficiency's Program Attribution Research

In 2002–2003, the Office of Energy Efficiency (OEE) completed impact attribution studies for EnerGuide for Houses and for its Dollars to $ense workshop series (a component of Energy Innovators and the Canadian Industry Program for Energy Conservation). Both of these studies employed analytical methods derived from Discrete Choice Theory, which has been used to estimate the change in behaviour that can occur (for an individual or a group of individuals) as a result of a firm's marketing efforts or a utility's program efforts. Discrete Choice Theory methods are only beginning to be applied to the evaluation of public sector programs. Both studies were aimed at estimating the market outcomes, measured in terms of energy savings and GHG emissions reductions that could be attributed solely to program efforts. The studies yielded positive and insightful results that not only allow program managers to gauge the effectiveness of their programs, but also allow the programs to be strategically improved in order to ensure even better outcomes in the future.

The Dollars to $ense study revealed that knowledge levels about how to improve energy efficiency improved significantly for workshop participants, who came from the commercial, private, public and industry sectors. The combined net impact of the three Dollars to $ense workshops (Energy Master Plan, Energy Monitoring and Tracking, and Spot the Energy Savings Opportunities) was a savings of 3.1 petajoules of energy use per year. The rate of uptake, or the installation of different energy efficiency improvement measures (e.g. the installation of more-efficient refrigerators or lighting), that could be attributed to the workshops ranged from 0.4 percent for ovens to almost 40 percent for compact fluorescent lights.

The EnerGuide for Houses (EGH) study also produced positive results. Overall, participants were very satisfied with EGH. Over two thirds of participants recommended EGH to a neighbour, friend or relative. Furthermore, close to 20 percent of participants had a neighbour, friend or relative also participate in EGH. Survey respondents indicated that EGH played an important role in their decisions to undertake various energy-saving home renovations. The study results showed that EGH was most influential in convincing homeowners to improve their foundation and ceiling insulation, mechanical ventilation systems and weather-stripping. The net impact in estimated energy savings ranges between 0.12 and 0.35 petajoules per year.

The OEE will continue to report on the progress of its performance assessment work in the coming years.

Chapter 4: Housing

Energy Use and Greenhouse Gas Emissions

The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling, heating water and operating appliances and lights. This sector accounts for 16.8 percent (1337 petajoules) of secondary energy use and 15.7 percent (74 megatonnes) of greenhouse gas (GHG) emissions.

Most dwellings in Canada are single detached houses, followed by apartments, single attached dwellings and mobile homes (see Figure 4-1). Because single detached and attached houses predominate, most Natural Resources Canada (NRCan) residential building programs focus on these dwellings.

Space and water heating make up 80.2 percent of residential energy use, followed by the shares devoted to operating appliances, lighting and space cooling (see Figure 4-2).

Between 1990 and 2001, residential energy use increased by 3.7 percent, or 47.5 petajoules (from 1289 to 1337 petajoules). From 1990 to 2001, GHG emissions from the residential sector increased by 6.8 percent. A 3.7 percent increase in energy use combined with a 6.8 percent increase in GHG emissions reflects an increase in GHG intensity. This was principally due to an increase in the carbon intensity of generated electricity.

Four main factors tended to influence residential energy use – activity, weather, structure and energy efficiency:

- activity – the increase in the number of households and the size of dwellings (the principal measures of residential activity) increased energy use by 21.7 percent (280 petajoules);
- weather – warmer weather in 2001 compared with 1990 led to a decrease in space-heating requirements. This decreased energy use by 2.2 percent (29 petajoules);
- structure – the percentage shares of energy end-uses changed over the period such that they increased energy use by 2.8 percent (37 petajoules); and
- energy efficiency – improvements in energy efficiency decreased energy use by 18.7 percent (241 petajoules).

FIGURE 4-1

Canadian Households by Type of Dwelling, 2001

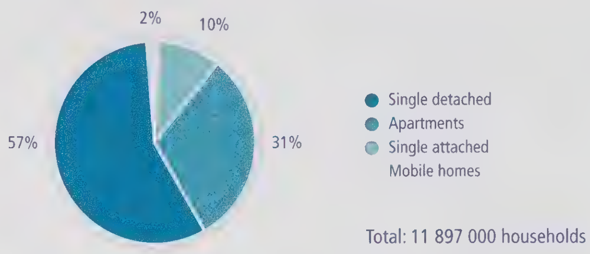
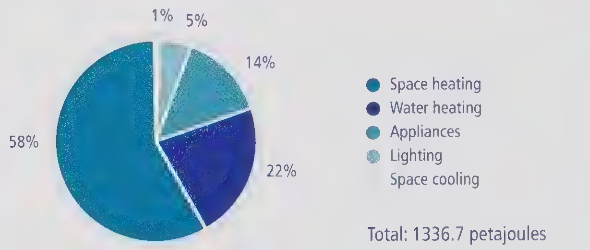


FIGURE 4-2

Residential Energy Use by Purpose, 2001



Growth in residential energy use was driven in large part by growth in activity. This increase was partially offset by significant improvements in energy efficiency. Structural changes had a minor impact on residential energy use.

The change in overall residential energy use from the years 1990 to 2001, as well as the energy savings due to energy efficiency, is shown in Figure 4-3. Figures 4-4 and 4.5 show how energy consumption differs for houses built to different standards and in different periods, reflecting improvements in building construction.

NRCan delivers initiatives to increase energy efficiency in the following residential subsectors:

- new houses;
- existing houses; and
- residential equipment, including
  - energy performance regulations; and
  - energy labelling.

FIGURE 4-3

Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001

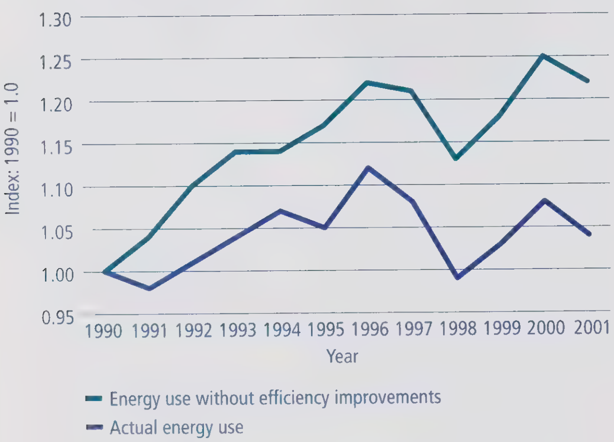


FIGURE 4-4

Annual Heating Consumption for Houses Constructed to Different Standards (From EnerGuide for Houses)

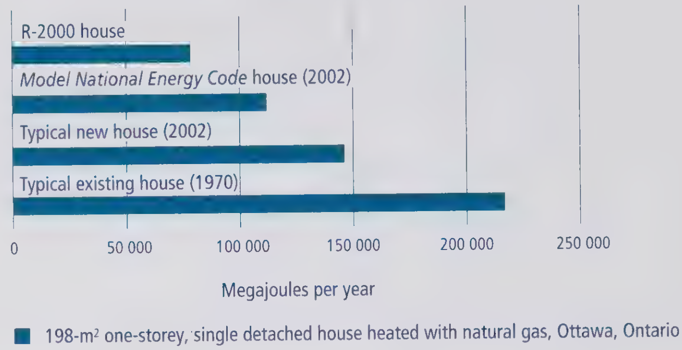
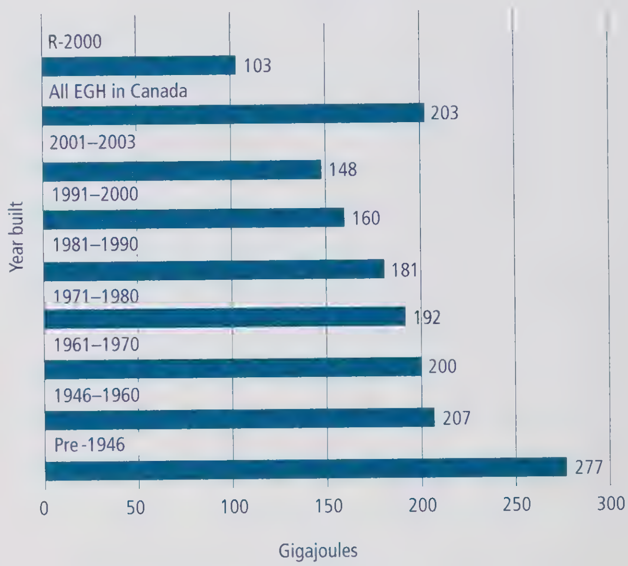


FIGURE 4-5

Average Energy Consumption per Household (From R-2000* and EnerGuide for Houses)



*R-2000 is an official mark of Natural Resources Canada.

New Houses: R-2000 Standard

Objective: To increase market adoption of energy-efficient new houses by promoting changes in construction practices.

The R-2000 Standard encourages Canadian builders to build, and Canadian consumers to purchase, more energy-efficient houses that are environmentally friendly and healthy to live in. Trained and licensed R-2000 homebuilders and other professionals commit to meeting the R-2000 Standard – a technical performance standard that exceeds the requirements for energy efficiency and environmental responsibility in current Canadian building codes.

Key 2002–2003 Achievements

- All previously trained professionals updated their skills, and eight new builders were trained to the revised R-2000 Standard.
- The updated R-2000 Standard introduced.
- National training and certification system implemented for R-2000 builders and service providers.
- Agreement signed with the Heating, Refrigeration and Air Conditioning Institute of Canada to support training. Subsidized courses offered to the industry to increase its capacity to design and install energy-efficient heating and ventilation systems.
- EnerGuide for Houses energy rating system piloted with tract builders.
- Agreements signed with new delivery partners from the Ontario First Nations Technical Services Corporation and the First Nations (Alberta) Technical Services Advisory Group to the Council in order to extend the R-2000 reach and capacity building on First Nations territories.

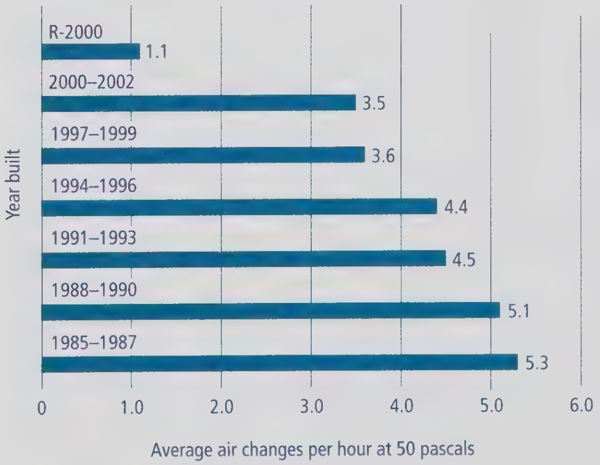
For more information:
oee.nrcan.gc.ca/r-2000/english/index.cfm

FIGURE 4-6

Number of Eligible R-2000 Housing Starts, 1990 to 2002

FIGURE 4-7

National Trends in Air Leakage in Houses (R-2000 and EnerGuide for Houses), 1985 to 2002



New Houses: Super E™ Program

Objective: To build capacity for exporting energy-efficient, durable and environmentally friendly Canadian housing technology to foreign markets.

The Super E™ Program is a strategic housing export initiative delivered by NRCan as part of the Team Canada export strategy. Launched in 1998, the Super E™ Program facilitates partnerships between Canadian builders and their foreign counterparts to increase market penetration of Canadian energy-efficient technologies internationally.

- To date, over 70 houses have been built in Japan, and 20 houses have been completed in the United Kingdom with contracts for over 60 more houses already confirmed for 2003–2004. This next year will also see Super E™ projects in Ireland and China.
- Over the past four years, sales generated through the Super E™ Program are estimated at a total of C$8 million. Sales in 2003 are expected to approach C$5 million.
- Over 22 Canadian companies from British Columbia to Prince Edward Island are partnered with over 30 foreign companies in Japan and the United Kingdom.
- NRCan is joined in this program by Canada Mortgage and Housing Corporation and the Department of Foreign Affairs and International Trade.

Key 2002–2003 Achievements

- Establishment of the Super E™ Housing Committee by Japanese members to increase sales of Super E™ houses in Japan.
- The opening of the first Super E™ home in Inverness, Scotland.
- A strategic partnership signed between the program and Zurich Home Warranty of the United Kingdom, where it is the largest home warranty company, will accelerate the adoption of Super E™ standards in the U.K. housing industry.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

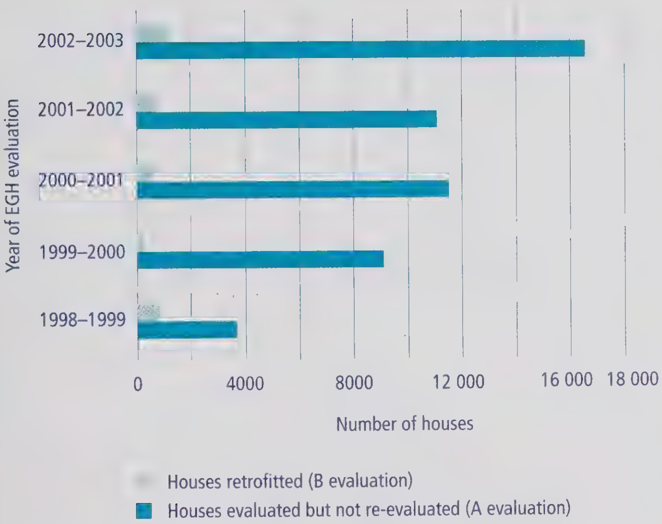
Existing Houses: EnerGuide for Houses

Objective: To encourage Canadians to improve the energy efficiency of their homes.

EnerGuide for Houses provides Canadians with the facts they need to improve the energy efficiency of their homes, especially when undertaking home renovation and maintenance projects. It offers homeowners personalized expert advice on how to improve the energy performance of their houses. EnerGuide for Houses was expanded under Action Plan 2000 to include new houses. Its primary purpose is to label new homes for energy performance.

FIGURE 4-8

Evaluations Under EnerGuide for Houses



Note: Under EnerGuide for Houses, homes are evaluated to determine the potential for energy savings (an A evaluation). After renovations implementing program recommendations have taken place, some homes are revisited to determine the actual energy savings (a B evaluation).

Key 2002–2003 Achievements

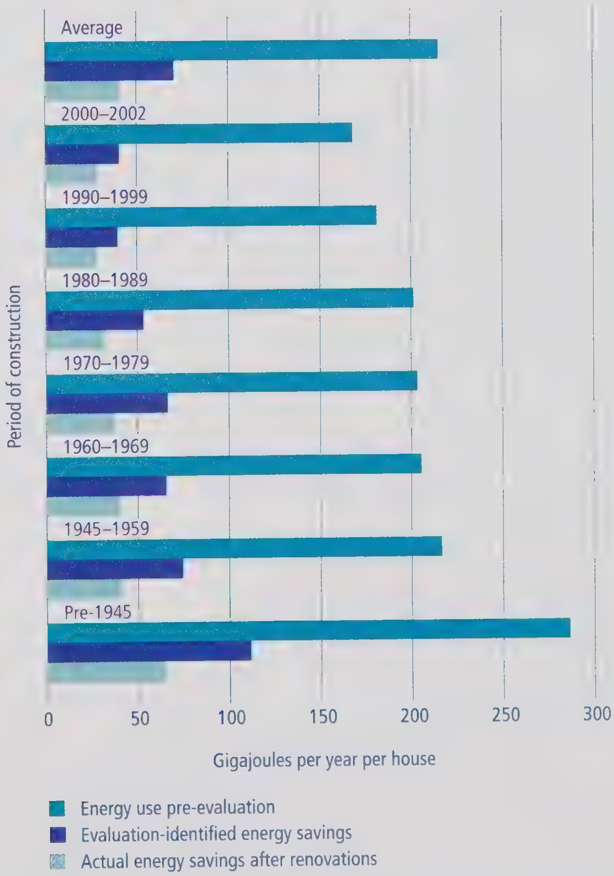
- Over 17 700 houses evaluated and labelled.
- Average annual energy savings of 19 percent for homes that undertook retrofit activities; for homes built before 1945, the savings increase to 23 percent.
- Over 90 percent client satisfaction rate with the EnerGuide for Houses service; 76 percent of clients said service "exceeded their expectations."
- Over 60 percent of the clients had implemented at least some of the recommendations by the time of a follow-up survey; an additional 23 percent said they "intended to retrofit."

For more information:

oee.nrcan.gc.ca/houses-maisons/english/choose_e.htm

FIGURE 4-9

Residential Energy Use and Energy Savings per Household



Residential Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy-performance levels and labelling requirements.

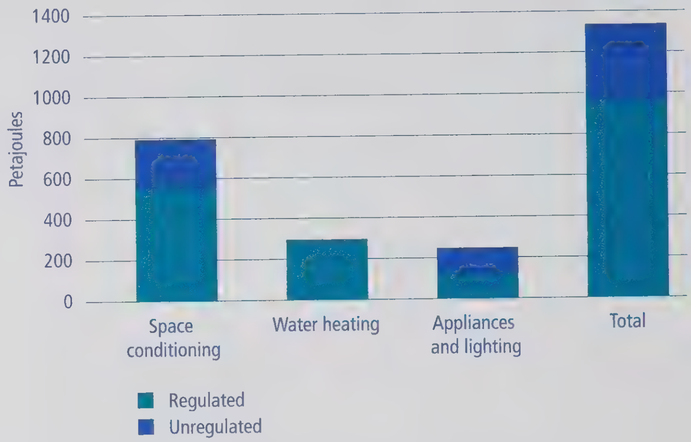
Key 2002–2003 Achievements

- Published seventh amendment to the *Energy Efficiency Regulations.*
- The Regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial-institutional sector.

For more information:
oee.nrcan.gc.ca/regulations/home_page.cfm

FIGURE 4-10

Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 2001



Residential Equipment: Labelling and Promotion

Objective: To promote the production, purchase and use of more energy-efficient equipment.

The Labelling and Promotion Initiative consists of labelling, rating and promotional activities that encourage manufacturers to produce, and consumers to purchase and use, more efficient energy-using equipment. The initiative is made up of EnerGuide for Equipment, which provides comparative information on the energy performance of major household appliances as well as heating, ventilating and air conditioning (HVAC) equipment, and the ENERGY STAR® endorsement label, which allows the consumer to identify the most energy-efficient products available based on a standard set of criteria.

Key 2002–2003 Achievements

- Labelling requirements are now extended to such products as gas fireplaces, windows and sliding doors.

For more information:
energuide.nrcan.gc.ca/ or hvac.nrcan.gc.ca/index_e.htm
or
energystar.gc.ca

FIGURE 4-11

ENERGY STAR® Label

Residential Equipment: Labelling and Promotion (continued)

FIGURE 4-12

Average Energy Consumption of New Appliances, 1990 and 2001 Models

FIGURE 4-14

Impact of EnerGuide Labelling: Total Energy Savings and GHG Emissions Reductions Attributable to EnerGuide for Equipment, 1990 to 2000

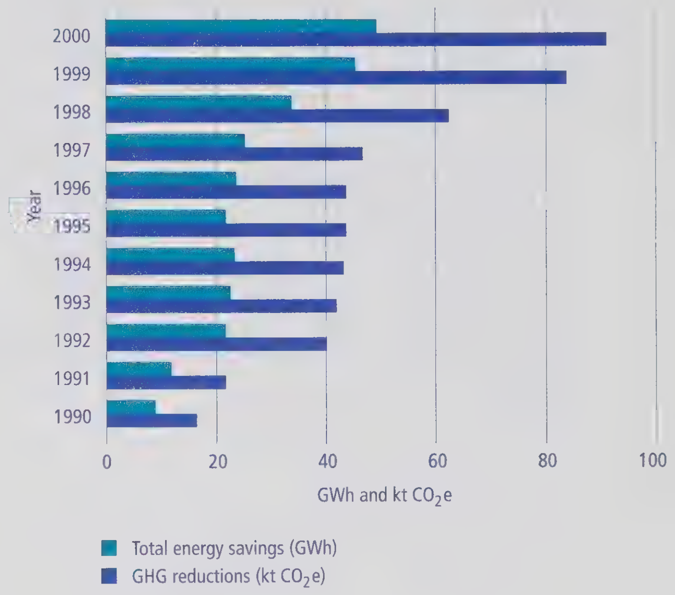
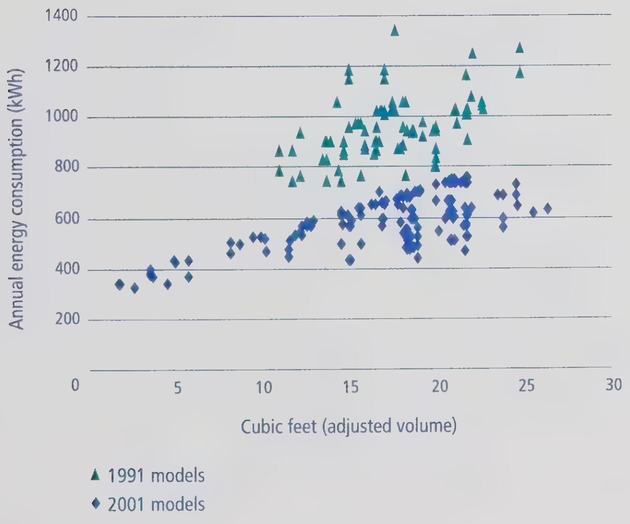


FIGURE 4-13

Unit Energy Consumption for Top-Mounted Auto-Defrost Refrigerators Marketed in Canada, 1991 and 2001 Models



Residential Equipment: Housing Energy Technology Program

Objective: To accelerate the development and market adoption of energy-efficient housing technologies.

The program works in partnership with associations, government and industry to develop and deploy highly specialized solutions that help reduce, in a cost-effective manner, the energy consumption and GHG emissions of Canadian houses.

- CETC Advanced Houses Program has led to the identification, accelerated development and broader deployment of a number of promising technologies, i.e. advanced integrated mechanical systems (now trademarked ēKOCOMFORT™) and electronically commutated motors (ECMs).
- CETC development and technical support of the R-2000 Standard has led to extensive technology development and deployment throughout the housing sector. Through its associated Building Energy Simulation Program, CETC's software tools are in use across the country.
- Accelerated development and adoption of low-emissivity coatings, insulated spacers and more energy-efficient frames for windows in new and existing houses. Engineering design tools, such as FRAME/Vision, have become a cornerstone of glazing thermal design and compliance with window energy-rating systems.
- CETC is a lead managing agency for the Canadian Centre for Housing Technology (CCHT), an advanced testing facility for assessing whole-house impacts of emerging technologies. The centre was built, and is managed in partnership with, the National Research Council Canada and Canada Mortgage and Housing Corporation.

Key 2002–2003 Achievements

- The CCHT has enhanced testing capacity to allow greater testing and development of emerging technologies like distributed power, renewable energy technologies and fuel cells. Development and assessment has also assisted advanced integrated mechanical systems, a wastewater heat recovery system, ECMs and Stirling engines.
- A government/industry collaborative research project at the CCHT has quantified the energy and homeowner benefits of ECMs. These motors significantly reduce the electrical consumption costs from running furnace fans on low speed.
- As ēKOCOMFORT™ units now begin to enter the market, the ēKOCOMFORT™ industry consortium is moving to formalize the voluntary performance standard as a full CSA International industry standard.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Chapter 5: Buildings

Energy Use and Greenhouse Gas Emissions

The commercial and institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services, including tourism. This sector uses energy mainly for space and water heating, space cooling, lighting, motive power for services such as pumping and ventilation in buildings, and street lighting.

In 2001, the commercial and institutional sector accounted for 13.3 percent (1054 petajoules) of secondary energy use and 13.0 percent (61.7 megatonnes) of greenhouse gas (GHG) emissions.

This sector comprises many building types (see Figure 5-1). Retail and office space account for more than half of commercial and institutional sector energy demand. Schools, health care facilities and hotels and restaurants account for another 26.2 percent of that demand. Natural Resources Canada (NRCan) programs address all of these major energy-using building types.

Energy is used for six purposes in commercial and institutional buildings. The largest of these is space heating, which accounts for more than half of this sector's entire energy demand (see Figure 5-2). Each of the remaining five uses of energy in this sector accounts for between 5.0 and 15.0 percent of its energy demand.

Between 1990 and 2001, commercial and institutional energy use increased by 21.5 percent, or 187 petajoules (from 867 to 1054 petajoules). However, GHG emissions from the sector rose by 29.1 percent in the same period. The main factor causing emissions to increase more quickly than energy use was the increased use of energy sources with a higher GHG content.

FIGURE 5-1

Commercial and Institutional Energy Use by Building Type, 2001

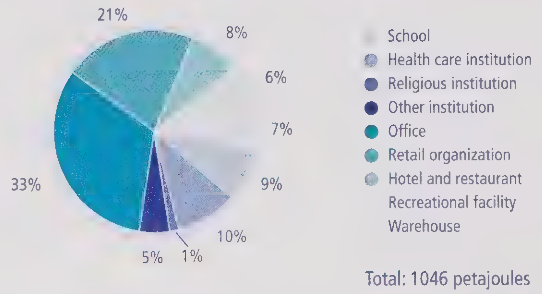


FIGURE 5-2

Commercial and Institutional Energy Use by Purpose, 2001

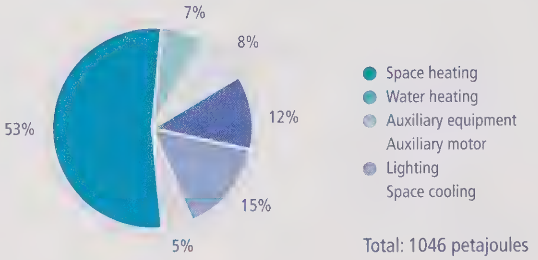


FIGURE 5-3

Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001

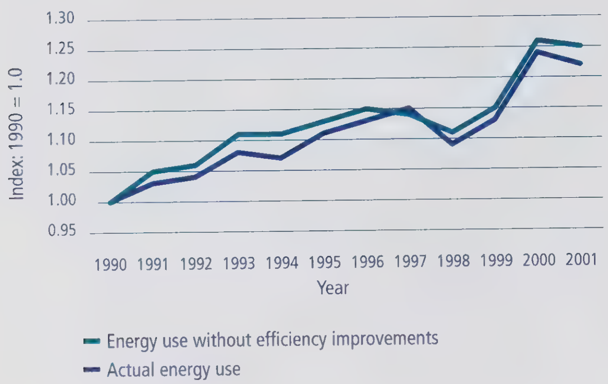
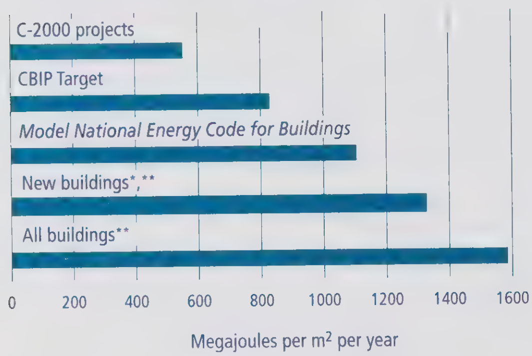


FIGURE 5-4

Energy Use in Commercial Buildings, 1999



* 1990–1999
** Source: Commercial and Institutional Building Energy Use Survey, 2000. Estimates relate only to the surveyed area of populations over 175 000 and in Atlantic Canada populations of over 50 000.

During 1990–2001, activity was the main factor tending to increase energy use; energy efficiency tended to decrease energy use. Structure (the mix of building types) and weather varied by only a minor extent. Specifically, the changes attributed to each of these factors are

- activity – an increase of 219 petajoules in energy use;
- weather – a decrease of 8 petajoules;
- energy efficiency – a decrease of 31 petajoules; and
- structure – an increase of 8 petajoules.

If only activity, weather and structure had been in effect, commercial and institutional energy use would have increased by 25.1 percent (219 petajoules). However, improvements in energy efficiency worked to decrease energy use by 3.6 percent (31 petajoules). As a result, energy use increased by only 21.5 percent. This change in energy use during 1990–2001, as well as the energy savings due to energy efficiency, is shown in Figure 5-3. Figure 5-4 shows how energy use in commercial buildings compares with certain standards.

NRCan delivers initiatives to increase energy efficiency in the following subsectors of the commercial and institutional sector:

- new buildings;
- existing buildings; and
- equipment.

New Buildings: Commercial Building Incentive Program

Objective: To improve the energy efficiency of new commercial, institutional and multi-unit residential buildings.

The Commercial Building Incentive Program (CBIP) provides financial incentives to builders and developers who incorporate energy-efficient features into the design and construction of new commercial, institutional and multi-unit residential buildings. To qualify for the incentive, buildings must be at least 25 percent more energy efficient than similar buildings constructed to the *Model National Energy Code for Buildings* (MNECB).

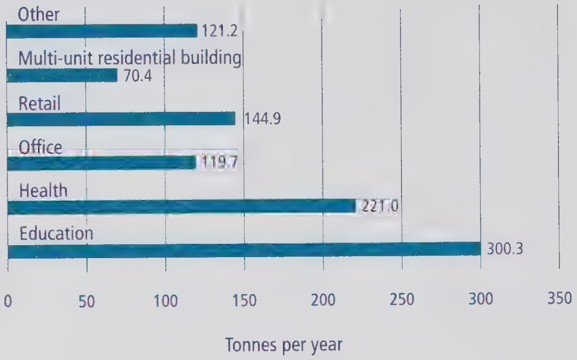
Key 2002–2003 Achievements

- 79 new contributions worth over $3.9 million in total were issued to building owners.
- CBIP buildings average 34.4 percent more energy efficiency than similar buildings constructed to the MNECB.

For more information:
oee.nrcan.gc.ca/newbuildings

FIGURE 5-5

Estimated Average GHG Reductions by Institution Under CBIP, 2002 to 2003



New Buildings: Industrial Building Incentive Program

Objective: To improve the energy efficiency of new industrial buildings.

The Industrial Buildings Incentive Program (IBIP) extends the precepts of CBIP to the industrial sector. IBIP offers an incentive to companies building new energy-efficient industrial facilities, to offset additional design costs inherent in the initial attempts at energy-efficient designs and building/process integration. The design is assessed against a reference generated from the MNECB.

Key 2002–2003 Achievements

- Nine contribution agreements were signed.
- 28 architects and engineers were trained on energy-efficient industrial building design.

For more information:
oee.nrcan.gc.ca/newbuildings

New Buildings: Green Buildings Program

Objective: To reduce energy use, resource consumption and emissions from commercial buildings through design, construction and retrofitting while increasing cost-effectiveness.

The program plays a significant role in establishing goals for energy efficiency and sustainability in commercial buildings through various activities, including C-2000, Green Building Challenge (GBC) and the Integrated Design Process (IDP). The team also provides technical support to NRCan initiatives like CBIP.

- The C-2000 Program has delivered the Mountain Equipment Co-op store in Winnipeg, Manitoba, which was awarded the *2002 Manitoba Sustainable Development Award of Excellence*.
- The CANMET Energy Technology Centre (CETC) launched GBC in 1996, leading more than 20 countries focused on the development and testing of an internationally accepted system for assessing the environmental performance of buildings. GBC is now managed by a third party and continues to grow. GBC process assessments are conducted with GBTool™, an electronic tool developed by NRCan. Results of assessments are then displayed at a series of conferences.
- CETC provides the necessary tools, guidelines and techniques through its IDP to facilitate advanced whole-building energy- and resource-efficient design. IDP leads industry to produce an optimized, integrated building design that fully takes advantage of building component synergies, avoids conflicting operation strategies and provides the owner with on-the-spot cost/benefit analysis for various energy-efficient options.

Key 2002–2003 Achievements

- The first of three phases of the largest, most complex building designed to CETC's C-2000 Program for Advanced Commercial Buildings was successfully completed – the new Red River College (RRC) Princess Street Campus in downtown Winnipeg, Manitoba.
- The Mayo School in Yukon Territory and the RRC Princess Street Campus in Manitoba represented Canada at the 2002 Green Building Challenge in Oslo, Norway, and demonstrated Canada's leadership position in green building.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Existing Buildings: Energy Innovators Initiative

Objective: To encourage commercial businesses and public institutions to become more energy efficient and reduce their GHG emissions that contribute to climate change.

The Energy Innovators Initiative (EII) helps commercial organizations and public institutions explore energy efficiency options and strategies, offering them access to tools and financial assistance to help reduce energy costs and improve competitiveness. Members join the EII by sending a letter to the Minister of Natural Resources that makes a commitment to energy efficiency.

Key 2002–2003 Achievements

- 59 new projects were signed.
- Over 700 organizations representing about 27 percent of the sector's floor space are Energy Innovators.

TABLE 5-1

Energy Innovators Initiative – Incentive Projects From 2001 to 2003

Federal incentive	$12.7 million
Client investment	$207.2 million
Annual energy savings ($)	$33.5 million
Annual energy savings (gigajoules)	2.8 million

For more information:
oee.nrcan.gc.ca/eii/home.cfm

Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy-performance levels and labelling requirements.

Key 2002–2003 Achievements

- Published sixth amendment to the *Energy Efficiency Regulations* to increase the minimum energy-performance standards for ballasts and room air conditioners and to establish minimum energy-performance standards for dry-type transformers and incandescent reflector lamps.
- The Regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial and institutional sector.

For more information:
oee.nrcan.gc.ca/regulations/home_page.cfm

Equipment: Labelling and Promotion

Objective: To promote the production, purchase and use of more energy-efficient equipment.

The initiative is made up of EnerGuide for Equipment, which provides comparative information on the energy performance of equipment – including heating, ventilating and air conditioning (HVAC) – and the ENERGY STAR® endorsement label, which allows the consumer to identify the most energy-efficient products available based on a standard set of criteria.

Key 2002–2003 Achievements

- Established the ENERGY STAR Initiative in Canada and promoted ENERGY STAR qualified products, office equipment, transformers, lighting and HVAC products used in the commercial and institutional sector.
- Established ENERGY STAR criteria for the Government of Canada and its partners' procurement and incentive programs in the commercial sector.

For more information:
energuide.nrcan.gc.ca/
or
hvac.nrcan.gc.ca/index_e.htm
or
energystar.gc.ca

Equipment: Buildings Program

Objective: To reduce energy consumption, synthetic refrigerant use and GHG emissions in buildings through the use of innovative technologies.

In partnership with stakeholders, the Buildings Program develops, demonstrates and deploys refrigeration technologies in Canadian supermarkets and ice and curling rinks, and intelligent-building technologies in the commercial and institutional sector. These efforts help to decrease energy consumption, synthetic refrigerant use and GHG emissions while maintaining good indoor comfort conditions.

Key 2002–2003 Achievements

- Organized a national workshop on refrigeration systems for supermarkets in March 2003 in Montréal, Quebec, which gathered more than 80 participants from the public and private sectors.
- Provided technical support in a program of prefeasibility studies of advanced refrigeration technologies in Quebec ice rinks, in collaboration with the Association des arénas du Québec inc., the Agence de l'efficacité énergétique du Québec, the Federation of Canadian Municipalities and Gaz Métropolitain.
- Initiated a demonstration project of innovative integrated HVAC and refrigeration technologies in a Loblaw's supermarket in Quebec.
- Organized a national workshop on building recommissioning titled "RECOM Canada 2003" in February 2003 in Ottawa, Ontario, that gathered more than 40 participants from private and public sectors.
- Successfully tested the Diagnostic Agent for Building Operators Fault Detection and Diagnosis module (DABO-FDD), a computerized tool that allows the detection and diagnosis of mechanical system defects in buildings, at CETC – Varennes and Aéroports de Montréal (Dorval). Aéroports de Montréal asked for DABO-FDD installation at the airport's new extension.

For more information:
cetc-varennes.nrcan.gc.ca/en/b_b/bi_ib.html

Equipment: Building Energy Simulation Program

Objective: To contribute to the improvement of design, performance, cost-effectiveness, integration and deployment of energy-efficient building technologies and techniques, through simulation modelling and applications-driven implementation tools for the market.

Through this program, the Simulation Team develops, distributes and supports building simulation software for the Canadian housing and building industry. These software tools are used by architects and engineers to optimize the energy performance of building designs and to demonstrate compliance with such programs as the R-2000 Standard, CBIP and the *Model National Energy Code for Buildings* and the *Model National Energy Code for Houses*. The team is involved in all aspects of the software development process, from design and programming to distribution, maintenance, user training and user support.

- Using CETC software, over 45 000 houses and 800 commercial buildings have been simulated for improved energy efficiency.
- NRCan is first in the world to have a fuel cell model integrated in a building simulation program. This model is an important tool for companies and governments to optimize distributed generation systems for buildings. The team has also initiated an annex of the fuel cell cogeneration task at the International Energy Agency, taking a lead role internationally in the validation of methods for modelling fuel cell cogeneration systems.
- The Simulation Team developed the next generation residential energy analysis software, HOT3000™, which is replacing HOT2000* with a more flexible and expandable core based on the ESP-r program. HOT3000™ can now meet the complex modelling needs of the breadth of energy-saving technologies and strategies entering the market and emerging in industry research and development (R&D). The ESP-r program was created by the University of Strathclyde in Scotland, which remains a collaborator on several simulation projects.

Key 2002–2003 Achievements

- The University Research Network has expanded to include the Canada Mortgage and Housing Corporation as a new partner.
- Building upon the first Canadian conference on building energy simulation (eSim) created by CETC, the network of industry, university and government volunteers organized eSim 2002.
- CETC released the latest version (v.9) of HOT2000, an energy analysis software. HOT2000 is widely used as a compliance tool for R-2000 home builders and EnerGuide for Houses delivery agents and as a general housing energy analysis tool by builders and housing researchers worldwide.
- The commercial building simulation software, EE4, has been customized for use by the Russian government and utilities in delivering conservation programs.
- NRCan developed two Web-based "wizards" that perform accurate building analysis of supermarkets and arenas, virtually and instantaneously, to support design decisions for these types of buildings. The "wizard" tools are part of the EE4 software suite, which is used to detail building data for submissions to CBIP.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

*HOT2000 is an official mark of Natural Resources Canada.

Community Energy Systems: Community Energy Systems Program

Objective: To increase the sustainability of Canadian communities by addressing their energy needs.

In partnership with Canadian communities and businesses, energy needs are addressed through a holistic approach to energy efficiency, renewable energy and community energy planning.

NRCan has supported many district energy projects, some of which are based on renewable energy, including those in Charlottetown, Prince Edward Island – biomass and municipal waste fuelled; Fort McPherson, Northwest Territories – cogeneration; Cornwall and Sudbury, Ontario – cogeneration; Windsor and Hamilton, Ontario – cogeneration, heating and cooling; Ajax, Ontario – using waste wood from industry; and Watson Lake, Yukon Territory, and Arviat, Nunavut, and many other northern communities – using waste energy from the local power plants.

NRCan helped design a heating system for the Cree community of Oujé-Bougoumou, in northern Quebec. The system uses sawdust from a local sawmill to provide over 90 percent of the energy, using oil as a backup. Carbon dioxide emissions have been reduced by an estimated 2300 tonnes per year.

NRCan is helping communities to develop Sustainable Community Energy Plans, using tools that are designed to reduce energy demand, emphasize conservation and promote reliance on local renewable energy sources.

Key 2002–2003 Achievements

- Continued to develop a community energy training program and held workshops in Halifax and Port Hawkesbury, Nova Scotia, and Thunder Bay, Ontario.
- Sponsored the Canadian District Energy Association Conference and the Federation of Canadian Municipalities' study tour to Europe.
- Established a microturbine-based R&D facility to test various heat-based cooling technologies. This "tri-generation" (electricity, heat and cooling) will increase the overall energy efficiency of distributed generating systems.
- Publication of two IEA reports: *District Heating and Cooling Connection Handbook* and *Optimization of District Heating Systems by Maximizing Building Heating System Temperature Difference*.
- Established a unique facility to determine the reduction of pressure drop in district energy pipelines and hydronic heating systems due to the application of friction-reducing additives, while simultaneously measuring heat transfer. Friction-reducing additives can reduce the pressure drop (and pumping power) in pipelines by up to 80 percent.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_ces_e.html

Chapter 6: Industry

Energy Use and Greenhouse Gas Emissions

The industrial sector includes forestry, construction and mining as well as all manufacturing. This sector uses energy in industrial processes as a source of motive power, to produce heat or to generate steam. Overall, industrial energy demand accounts for 38.5 percent (3064 petajoules) of secondary energy use and 33.6 percent (159 megatonnes) of greenhouse gas (GHG) emissions (including electricity-related emissions).

Within the industrial sector, energy is consumed primarily in the pulp and paper, other manufacturing, and mining industries. Pulp and paper alone accounted for almost 30 percent of total industrial energy demand in 2001 (see Figure 6-1).

In most industries, energy purchases account for only a small proportion of total expenditures. However, for some relatively energy-intensive industries – cement, chemicals, pulp and paper and aluminum – this share is higher than 13 percent (see Figure 6-2). For cement, in particular, the share is as high as 38 percent.

After decreasing slightly in 1990–1991 as a result of the recession, industrial energy use had increased by about 11.2 percent (309 petajoules) by 2001 (from 2755 petajoules in 1990 to 3064 petajoules in 2001).

Due to data limitations as Statistics Canada converts to a new industrial classification system, the analysis of factors affecting energy use was done using 1995 as the base year. Between 1995 and 2001, industrial energy use increased by 3.0 percent, or 90 petajoules. The main factor that increases industrial energy use is activity:

- activity – a 22.4 percent increase in industrial activity resulted in a 664.6-petajoule increase in energy use; and
- structure – the change in the mix of activity toward less energy-intensive industries (such as electric and electronic) resulted in a 343-petajoule decrease in energy use.

FIGURE 6-1

Industrial Energy Use by Subsector, 2001

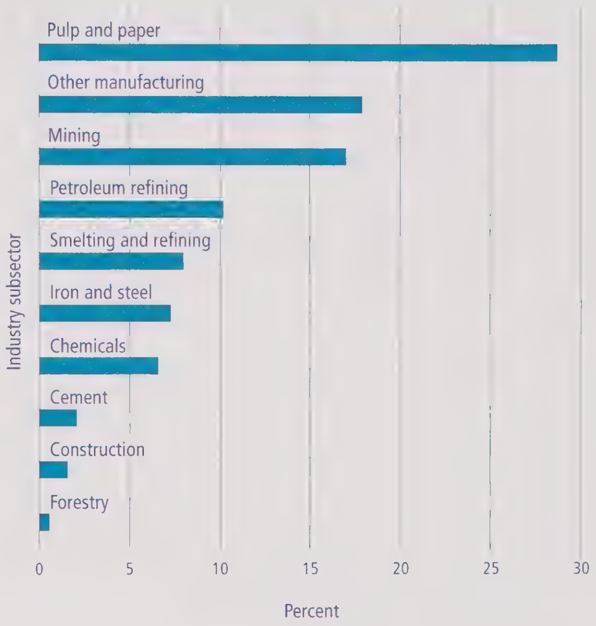


FIGURE 6-2

Cost of Energy to Industry as a Percentage of Total Production Cost, 2001

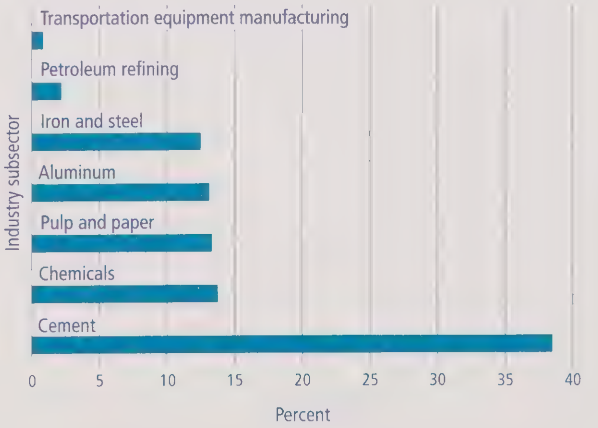
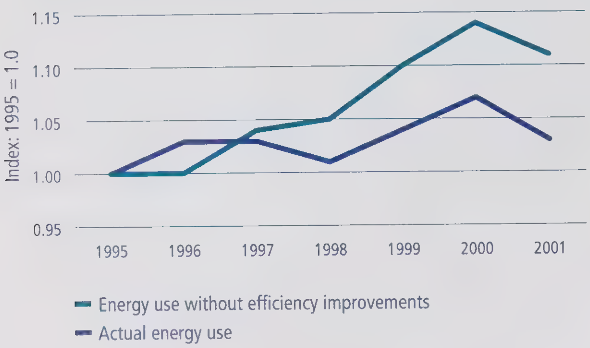


FIGURE 6-3

Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1995 to 2001



Improvements in the energy efficiency of the industrial sector avoided 231.8 petajoules of energy use over 1995–2001. As a result, energy use increased by only 3.0 percent. This change in energy use between 1995 and 2001 and the energy savings due to energy efficiency are shown in Figure 6-3.

Including electricity-related emissions, industrial GHG emissions increased by 10.6 percent. However, excluding electricity-related emissions, industrial GHG emissions over the same period increased by only 0.8 percent.

Natural Resources Canada (NRCan) delivers initiatives to increase energy efficiency in the following subsectors of the industrial sector:

- industrial processes and technologies; and
- equipment.

Industrial Processes and Technologies: Industrial Energy Efficiency

(Canadian Industry Program for Energy Conservation [CIPEC] and Industrial Energy Innovators [IEI])

Objective: To help Canadian industry use energy efficiency investments to improve competitiveness and to contribute to Canada's climate change goals.

CIPEC, a sector-level program, and IEI, a company-level program, both address barriers to planning, implementing, tracking and reporting energy efficiency projects in industry. Key elements include the establishment and tracking of energy efficiency improvement targets and plans, and the development of products and services that overcome barriers to continued energy efficiency improvement. NRCan provides support via employee awareness kits and events, best-practices guides, technical information, energy audits, benchmarking and workshops on energy management.

CIPEC targets all of industry, including mining, manufacturing, construction and forestry as well as upstream oil and gas and electricity generation.

Key 2002–2003 Achievements

- Between 1990 and 2001, the mining, manufacturing and construction sub-sectors achieved an average energy-intensity improvement of 1.8 percent per year and reduced their greenhouse gas (GHG) emissions related to energy use (excluding electricity-related emissions) to 8.4 percent below 1990 levels.
- The total fuel savings for 2001 amounted to $2.8 billion.
- Established three task forces; namely, Upstream Oil and Gas, Construction and Electrical Generation.

For more information:
oee.nrcan.gc.ca/cipec/ieep/

FIGURE 6-4

Industrial Energy Innovators and Action Plans, 1999–2000 to 2002–2003

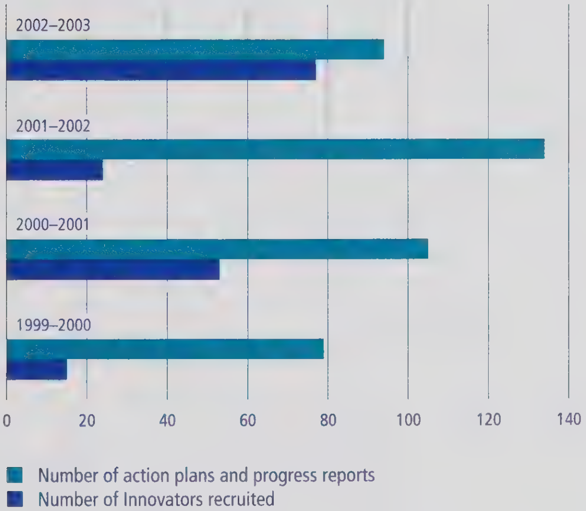


FIGURE 6-5

Mean Five-Year Increases in Energy Consumption, CIPEC Participants vs. Non-Participants

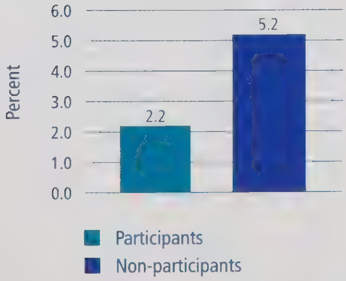
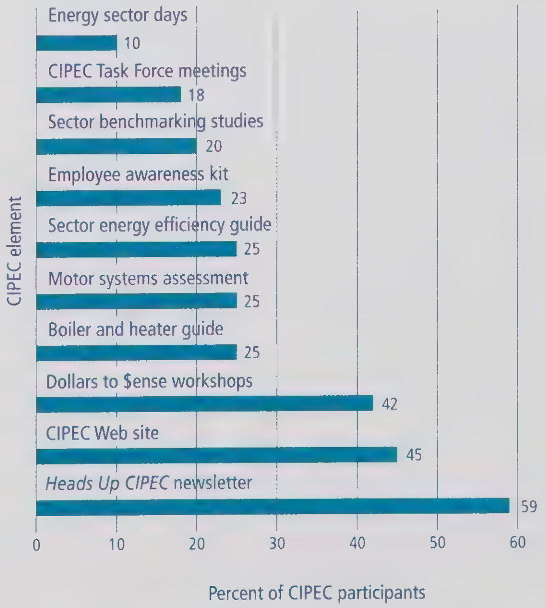


FIGURE 6-6

Level of Participation in Elements of CIPEC



Industrial Processes and Technologies: Advanced Combustion Technologies

Objective: To help industry develop cleaner, more energy-efficient combustion processes, with lower emissions of acid rain precursors, GHGs, particulates and identified priority substances – trace elements and organic compounds.

Research focuses on optimizing the performance of stationary combustion equipment and developing and evaluating new products, fuels and retrofit technologies, using conventional fuels – oil, coal and natural gas – as well as biomass and specialty fuels.

Key 2002–2003 Achievements

- Tested and optimized a Canadian technology to remove SO_2 and NO_x pollutants from the flue gases of coal-fired boilers while producing fertilizer as a byproduct.
- In cooperation with Canadian utilities, boiler manufacturers, the International Energy Agency, air separation equipment manufacturers and the U.S. Department of Energy, Advanced Combustion Technologies designed and implemented experiments and pilot plant tests to investigate burning various coals with oxygen-enriched air as part of an overall integrated emissions abatement approach to capturing/reducing NO_x, SO_x, mercury and GHGs.
- Held the first of three workshops to develop the Clean Coal Technology Roadmap for Canada.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_act_e.html

Industrial Processes and Technologies: Processing and Environmental Catalysis Program

Objective: To solve industrial process problems and undertake research in areas with high potential for significant environmental and economic benefits.

The program's facilities, including semi-pilot scale plants, are used for process testing and the evaluation of novel concepts in chemical and energy conversion, including hydrogen production from hydrocarbon and renewable sources. Clients include oil and gas companies, petrochemical companies, original engine manufacturers, waste oil renderers and specialty ceramic manufacturers.

Key 2002–2003 Achievements

- Development of high-temperature ceramic membranes for hydrogen separation. Target performance was achieved. This is an enabling technology to improve productivity and energy efficiency during hydrogen production and in the petrochemical industry.
- Development of a new generation fuel cell reactor technology that targets improved energy efficiency during synthesis gas production and hydrogen generation, in collaboration with National Research Council Canada and NRCan's CANMET Materials Technology Laboratory.
- Development of a technology for the production of low-sulphur, high-cetane blending stock from waste restaurant grease and vegetable oils. Engine testing of fuels blended with this oil is underway. The Government of Ontario participated in developing applications to soy oil as a feedstock.
- Initiation of a research program on low-temperature hydrogen production from biomass streams.
- Initiation of a research program on carbon-free ammonia fuel cells.
- Patented a technology on the conversion of low-grade waste heat to electricity for increased industrial plant efficiency.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_pec_e.html

Industrial Processes and Technologies: Industrial Process Engineering Program

Objective: To enable industry to continuously improve its energy efficiency and productivity, while decreasing emissions of GHGs and other pollutants.

The program focuses on industrial drying and catalytic flow reversal reactor technology. It seeks to meet its objective by performing leveraged research and development (R&D), introducing novel technologies, performing incremental improvements, performing industrial audits and disseminating technical information.

Key 2002–2003 Achievements

- The team working on the catalytic flow reversal reactor (CH4MIN) received the 2002 Public Service Award of Excellence. The CH4MIN technology will help reduce GHG emissions from coal mines.
- Published an evaluation of wood kiln control practices in Canada.
- With the International Energy Agency, initiated an annex on drying technology. Eight countries, led by Canada, are participating in the annex and working on three topics related to efficient drying.
- Adapted the jet-spouted bed-drying technology for processing food and agri-food products. This energy-efficient technology was developed in collaboration with Manitoba Hydro, to improve the quality of dried products in food processing plants.

For more information:
cetc-varennes.nrcan.gc.ca/en/indus.html

Industrial Processes and Technologies: Industrial Process Integration Program

Objective: To support the development and adoption of process integration in various industries.

The program focuses on methodologies for combined heat-and-power optimization, total-site optimization, batch-processes optimization and water-pinch optimization in the agri-food, pulp and paper and textile industries, and on the building of international-calibre Canadian capacity in process integration.

Key 2002–2003 Achievements

- Developed and hosted a two-day course on optimizing industrial cogeneration and managing site utility systems aimed at industry, utility providers, consultants and government representatives.
- Completed a process integration study at the Norampac Inc. paperboard mill in Red Rock, Ontario. Reduction of annual production costs by $3.6 million, with a payback period of less than 12 months, and GHG emissions reduction of about 25 000 tonnes per year.
- Started process integration studies in the Rolland Paper Mill in Saint-Jérôme, Quebec, and the Kruger Newsprint Mill in Bromptonville, Quebec.
- In collaboration with NRCan's Office of Energy Efficiency, completed a pan-Canadian consultation to identify the following: the importance of energy efficiency in Canadian industries; the role that process integration might play in Canadian companies; and the activities for the Government of Canada to prioritize to better meet the needs of companies.
- Developed a program aimed at promoting the knowledge and application of process integration techniques in Canadian industry.

For more information:
cetc-varennes.nrcan.gc.ca//en/indus.html

Industrial Processes and Technologies: Industry Energy Research and Development (IERD) Program

Objective: To encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, products, systems and equipment in industry.

Financial support is provided for commercially confidential applied R&D activities, which is repayable if the project is commercially successful. Program clients from all industrial sectors range from small- and medium-sized companies to multinational corporations.

Key 2002–2003 Achievements

- Turbocor Inc. of Montréal, Quebec, has developed an oil-less, non-chlorofluorocarbon compressor for refrigeration applications. This represents a breakthrough in industrial and commercial refrigeration and is generating energy savings of 30 percent. Turbocor won a Canada's Energy Efficiency Award in early 2003.
- Société des technologies de l'aluminium du Saguenay (STAS) in Chicoutimi, Quebec, is developing, in partnership with Lauralco in Deschambault, Quebec, an automated anode replacement and positioning system. This system will increase energy efficiency of the aluminium smelting process and reduce GHG emissions.
- Sorentec, in Québec, Quebec, is a new company specializing in cooling technology. It has developed new equipment for the rapid cooling of processed foods. The energy savings with the newly available commercial kitchen blast chillers is about 40 percent compared with conventional technologies.
- Airborne Pollution Control Inc. of Calgary, Alberta, is developing an energy-efficient sodium-based flue gas cleaning system for coal-powered generating plants. The project will demonstrate that coal with higher than desirable sulphur level can be used. The resulting flue gas can then be cleaned in a manner to eliminate SO_x as well as reduce NO_x and particulate emissions. Products recuperated from the gas cleaning are further processed and transformed into chemical fertilizers.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/factsheet_industry_energy_research_and_development_program_e.html

Industrial Processes and Technologies: Emerging Technologies Program (ETP)

Objective: To support the identification and demonstration of new and emerging energy-efficient technologies.

Projects are co-managed and cost-shared with industry and other stakeholders, such as gas and electric utilities, other governments and equipment manufacturers. Financial support is provided for the development and testing of pilot plants, prototypes and full-scale field trials to evaluate operating performance, energy efficiency and environmental impacts. NRCan's financial support is repayable from any cost savings or revenues realized from a project.

Since 1991, ETP and its forerunner, the Industrial Targeted Program, have contributed $19 million to 105 projects worth $143 million, mostly within the industrial sector.

Key 2002–2003 Achievements

- Ontario Power Generation concluded a study and pilot installation of Fuel Lean Gas Reburn™ technology applied to the 4000-megawatt coal-fired power plant at Nanticoke, Ontario. The project was co-financed by NRCan and Union Gas Limited and involved innovative computer simulation prior to pilot installation. Testing and modelling work concluded that with a 7 percent injection of natural gas, NO_x reductions of 30–35 percent are achievable.
- NRCan is supporting Ishmail Seating Components Inc. of Mississauga, Ontario, in its development of a production-scale process that recycles polymer waste material into moulded seating components. Pressure

on landfill sites will be alleviated and substantial energy reduction will be achieved by bypassing the conventional waste-reclamation process. Energy will also be saved by eliminating the production of plywood seating components.

- NRCan supported Sustainable Energy Technologies Ltd. of Calgary, Alberta, to complete the development and demonstration of a power inverter and DC converter for grid interactive solar photovoltaic applications and other renewable and alternative energy technologies.
- NAVA Composites Inc. of Vancouver, British Columbia, completed sea trials on a 38-foot (11.6-metre) prototype sport and/or fishing boat with support from NRCan. The substantially lighter weight of hull and key components, minimized hull resistance and improved thrust efficiency provide up to 40 percent fuel savings.
- NRCan supported Vehicle Projects LLC, in Denver, Colorado, in its Phase 1 Prototype and Preliminary Work of developing and testing the world's first fuel-cell-powered mine loader. This project involves 10 international partners and is funded by government (the U.S. Department of Energy and NRCan) and the private sector.
- Westport Research Inc. of Vancouver, British Columbia, with NRCan support, has delivered and installed a natural gas engine for stationary power generation to Grande Prairie, Alberta. A one-year field trial of a low-emissions (17.8 percent less carbon dioxide) natural gas engine for stationary power generation utilizing the Westport high-pressure direct injection technology is underway at the water/wastewater treatment facility in Grande Prairie.
- Participation with several leading Canadian utilities in the Canadian Clean Power Coalition to study, develop and demonstrate clean coal technology for power generation.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/funding_programs_etp_e.html

Industrial Processes and Technologies: Energy Technologies for High-Temperature Processes (EHTP)

Objective: To investigate technologies and develop knowledge to ensure the sustainability of Canada's coal, carbon and metallurgical industries.

EHTP has expertise in carbonization, combustion, agglomeration, thermal rheology, petrography and environmental and carbon science technologies to address energy efficiency, GHG reduction and related needs of industry. Key areas include alternative iron-making technology, fuel products, iron and steel process efficiency, standardization and analysis of emissions.

Key 2002–2003 Achievements

- EHTP experimentally evaluated the suitability of blending Canadian and Indian coals to make high-quality coke for the Steel Authority of India Limited (SAIL). The experimental work shows that models developed earlier at the CANMET Energy Technology Centre accurately predict the quality of coke made from blends of coals from Canada, India and Australia. The results of this work were presented to the SAIL representative in New Delhi on December 12, 2002. As a result of this presentation, SAIL has removed technical specifications that prevented Canada from selling coking coal to India.
- The quality of cokes from three Canadian coke plants has been evaluated by EHTP and compared with coke quality from best practices. As a result, Dofasco Inc. has set targets for improved coke quality to improve energy efficiency and achieve GHG reduction targets.
- EHTP has begun new research studies with the Canadian metallurgical coal industry with the aim of developing more competitive, more energy-efficient and better metallurgical coal products by blending coals from different Canadian mining properties before exporting the coals.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_ehtp_e.html

Industrial Processes and Technologies: Minerals and Metals Program

Objective: To reduce GHG emissions from four targeted areas in the Minerals and Metals Sector by a proposed 1.65 million tonnes per year over five years (2001–2002 to 2005–2006).

The Minerals and Metals Program under the *Government of Canada Action Plan 2000 on Climate Change* is part of the $500-million federal initiative over five years in support of Canada's *National Implementation Strategy on Climate Change* and *Canada's First National Climate Change Business Plan*. The Program is implemented by the CANMET Mining and Mineral Sciences Laboratories and allocates $10 million to four initiatives: (1) Supplementary Cementing Materials ($1.1 million); (2) Concrete for Roads ($3.5 million); (3) Studies/Monitoring for GHG Reduction ($2 million); and (4) Enhanced Recycling Technologies ($3.4 million). These four elements are overseen by a steering committee with representatives from NRCan (chair), Environment Canada and Industry Canada. Each of these four areas has a separate advisory committee consisting of experts in the field and representatives of interested industry and government groups.

Key 2002–2003 Achievements

- The goal of the Enhanced Recycling Program is to increase the recycling of aluminum by 100 000 tonnes per year (t/yr) by 2010 and the recycling of steel by 200 000 t/yr by 2010, yielding total GHG reductions in carbon dioxide equivalent (CO_2e) of 700 000 t/yr. The Enhanced Recycling Program has raised awareness of recycling, both actual and potential, among a broad group of stakeholders across Canada, especially at the municipal and regional level.
- Work to date under the Studies/Monitoring measure has identified areas of significant potential reductions in GHG emissions: (a) replacement of diesel power by fuel cells in mining, with estimated savings of up to 1 million t/yr; (b) alternatives to SF_6, a powerful GHG used in magnesium production, with associated savings of up to 1 million t/yr CO_2e; (c) cogeneration of electricity from off gases (e.g. steel production); and (d) replacing lime in mine effluent treatment with cement kiln dust, with approximate reductions of 0.2 million t/yr. In the long term, inert anodes in aluminum production could save an additional 10 million t/yr.
- A baseline study on the current use of Supplementary Cementing Materials (SCMs) has been completed. SCMs are used in concrete production to replace Portland cement. Each tonne of Portland cement replaced saves about one tonne of CO_2.
- Recent work on behalf of the Cement Association of Canada indicates that vehicles, especially heavy trucks, use 15 percent less fuel on a rigid concrete surface compared with a flexible asphalt surface. Studies suggest that replacing highways on the National Highway System with a concrete surface would reduce CO_2 emissions by 0.9 million t/yr. Action Plan 2000's Concrete Roads Program has undertaken a validation study to verify and expand on this historical data, in cooperation with National Research Council Canada.

For more information on SCMs:
www.ecosmart.ca

Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy performance levels and labelling requirements.

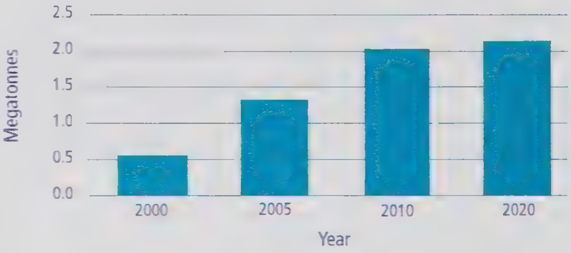
Key 2002–2003 Achievements

- Published sixth amendment to Canada's *Energy Efficiency Regulations* to increase the minimum energy performance standards for ballasts and room air conditioners and to establish minimum energy performance standards for dry-type transformers and incandescent reflector lamps often used in the industrial sector.

For more information:
oee.nrcan.gc.ca/regulations/home_page.cfm

FIGURE 6-7

Estimated Reduction in CO_2 Emissions From Motor Regulations, 2000 to 2020



Equipment: Labelling and Promotion

Objective: To promote the production, purchase and use of more energy-efficient equipment.

The initiative is made up of EnerGuide for Equipment, which provides comparative information on the energy performance of equipment – including heating, ventilating and air conditioning (HVAC) – and the ENERGY STAR® endorsement label, which allows industrial purchasers to identify the most energy-efficient products available based on a standard set of criteria.

Key 2002–2003 Achievements

- Initiated the development and promotion of Internet-based decision-making tools for industrial purchasers of electric motors and other energy-using equipment.

For more information:
energuide.nrcan.gc.ca/
or
hvac.nrcan.gc.ca/index_e.htm
or
energystar.gc.ca

Equipment: Mine Ventilation

Objective: To reduce energy consumption associated with mine ventilation by using the concept of "ventilation on demand," ventilation infrastructure automation and ventilation network optimization and management.

Providing ventilation to dilute and remove pollutants at a suitable working temperature accounts for about 40 percent of the energy consumed underground by a mining operation. This energy is consumed either as electricity by the primary and auxiliary fans or air conditioning (cooling) systems or from fossil fuels for heating sub-zero winter air. Historically, mine ventilation systems were designed to run at maximum flow 24 hours a day and seven days a week year-round due to a lack of control flexibility. This is gradually changing. Furthermore, within the energy consumption are linear-through-to-cubic relationships between a given airflow reduction and the power savings that ensue. This makes ventilation management a worthwhile endeavour economically and environmentally. Today, however, the benefits have to be determined on a case-by-case basis due to the numerous qualifiers involved. For the future, NRCan is looking to improve this evaluation process through the use of "production simulators."

Key 2002–2003 Achievements

- Feasibility study of using "ventilation on demand" within INCO Limited's Creighton Mine's deep ore zone to minimize ventilation costs and avoid the need for mechanical refrigeration.
- NRCan scientist has begun Ph.D. studies at the University of British Columbia in collaboration with an industrial partner. The thesis deals with linking mine-ventilation delivery and modelling with computerized mine-production simulation models to reduce ventilation costs.

For more information:
nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mines/air/air-e.htm

Chapter 7: Transportation

Energy Use and Greenhouse Gas Emissions

The transportation sector consists of three subsectors: passenger, freight and off-road. Passenger and freight transportation accounted for 57.8 percent and 38.5 percent, respectively, of transportation energy use, with off-road representing only 3.6 percent in 2001. The passenger subsector is composed of three modes: road, rail and air. The freight subsector, as defined by Natural Resources Canada (NRCan), comprises road, rail and marine. Road transport uses the most energy, accounting for 77.8 percent of total transportation energy use in 2001. Of this amount, 61.8 percent was passenger energy use and 38.2 percent was freight energy use (see Figure 7-1). All NRCan transportation energy-use programs focus on the energy used in road transportation.

Transportation energy use increased by 21.3 percent (399 petajoules) over 1990 to 2001 (see Figure 7-2). Passenger transportation energy use increased by 8.9 percent (108 petajoules), while freight transportation energy use increased by 42.5 percent (262 petajoules). Two main factors were responsible for this increase – activity and structure:

- activity – due to increases in population and economic activity, there was greater transportation activity (measured as passenger-kilometres for passenger transportation and tonne-kilometres for freight transportation). This increased transportation energy use by 19.3 percent (344 petajoules). The freight and passenger segments contributed to this increase by 71.3 percent and 28.7 percent, respectively; and
- structure – shifts between modes of transport were significant in passenger (where there has been a sharp increase in the stock of light trucks) and freight (where freight trucks are growing significantly faster than rail and marine) segments, resulting in an increase of 12.1percent in transportation energy use (215 petajoules).

FIGURE 7-1

Transportation Energy Use by Mode, 2001

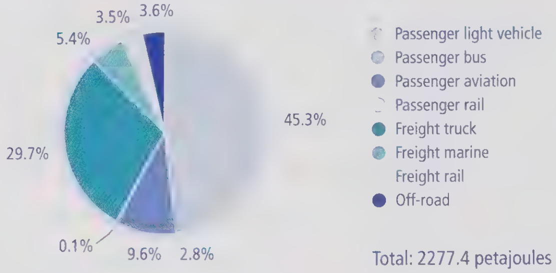


FIGURE 7-2

Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001

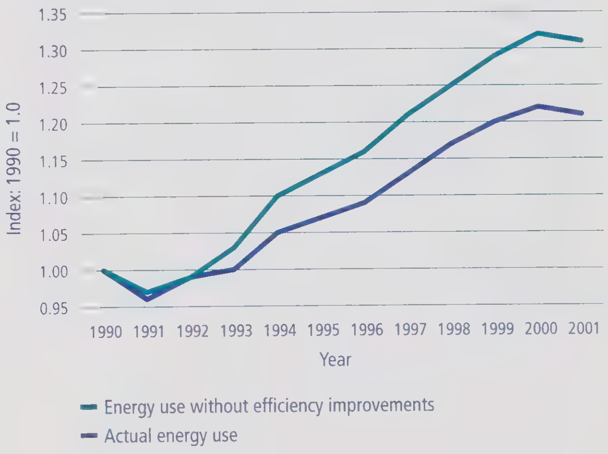


FIGURE 7-3

Market Shares of New Passenger Car and Light Truck Sales, 1990 to 2001

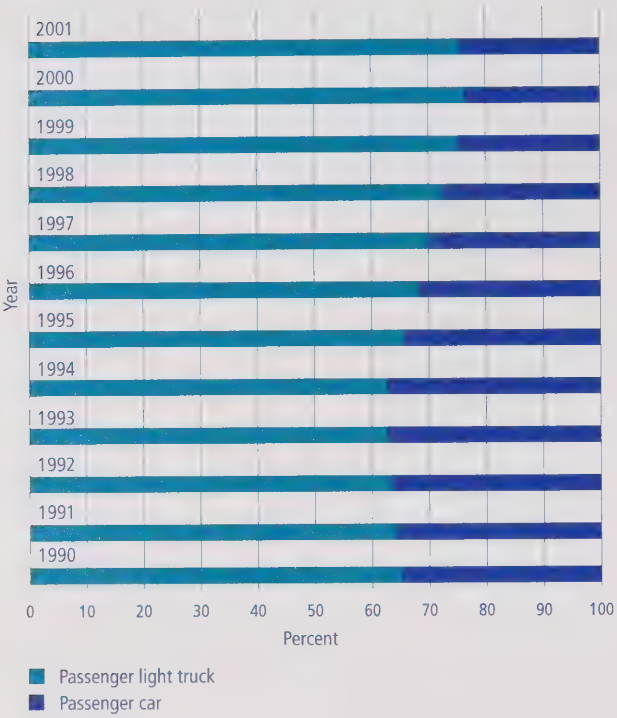
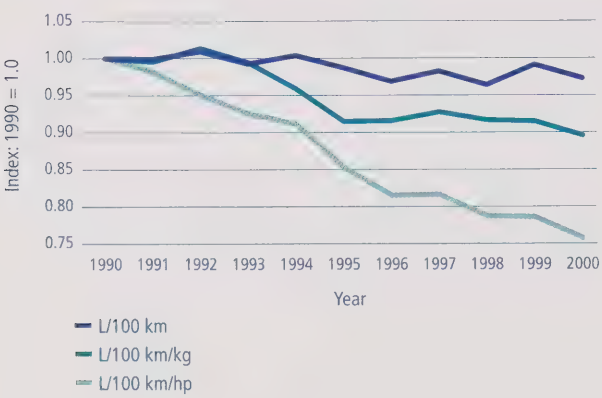


FIGURE 7-4

New-Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 2000



If only activity and structure had changed, transportation energy use would have increased by 31.3 percent (559 petajoules). However, improvements in energy efficiency worked to decrease energy use by 10.2 percent (181 petajoules). As a result, energy use increased by only 21.3 percent. This change in energy use between 1990 and 2001, as well as the energy savings due to energy efficiency, is shown in Figure 7-2.

The transportation sector accounts for 28.6 percent (2277 petajoules) of secondary energy use and 34.4 percent (163 megatonnes) of greenhouse gas (GHG) emissions. From 1990 to 2001, transportation energy use increased by 21.3 percent, and GHG emissions increased by 20.7 percent. The change in GHG intensity of transportation energy use was negligible.

Figure 7-3 shows how the market share of new light trucks has increased over the period, reflecting the growth in popularity of sport-utility vehicles (SUVs) and minivans. However, the market shares seem to have stabilized in the past two years. Figure 7-4 demonstrates that on a per-kilogram or per-unit-of-horsepower basis, fuel efficiency has improved markedly. However, average fuel economy has been stable because new vehicles continue to get heavier and sport more powerful engines.

NRCan delivers initiatives in the following areas to increase the efficiency of motor vehicles and encourage the use of alternative fuels:

- personal vehicles;
- fleet vehicles;
- transportation research and development (R&D);
- alternative transportation fuels; and
- transportation technologies.

Vehicles: Vehicle Efficiency

Objective: To improve the fuel efficiency of new motor vehicles.

This initiative, Vehicle Efficiency, is intended to bring about a 25 percent improvement in the fuel efficiency of new light-duty vehicles sold in Canada by 2010. NRCan is leading negotiations with the automotive industry and the United States to reach agreement on a voluntary fuel efficiency target for new vehicles. The initiative is seeking improvements in fuel efficiency starting as early as 2004. GHG reductions of about 5.2 megatonnes in 2010 are also being sought.

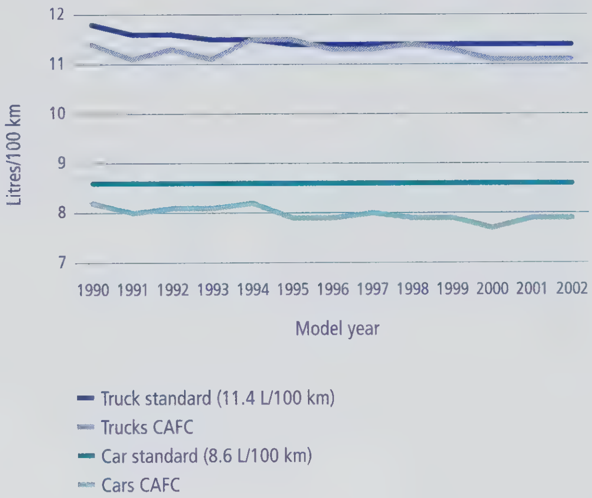
Key 2002–2003 Achievements

- A joint study by NRCan and the U.S. Department of Energy was published, entitled *Examining the Potential for Voluntary Fuel Economy Standards in the United States and Canada*. Presentations have been given at conferences and workshops on the findings of the study.

For more information:
oee.nrcan.gc.ca/english/programs/motorvehicles.cfm

FIGURE 7-5

Company Average Fuel Consumption (CAFC) vs. Canadian Voluntary Standards



Vehicles: Personal Vehicles

Objective: To improve motor vehicle fuel efficiency by encouraging private motorists to develop energy-efficient vehicle purchase, use and maintenance practices.

Personal Vehicles promotes awareness among Canadian motorists on the importance of improving vehicle fuel efficiency to reduce vehicle emissions and mitigate other vehicle-related environmental impacts. The initiative helps motorists understand how their automobile purchases and driving and maintenance habits affect climate change and the environment. It does this through various kits, guides, information dissemination and educational activities and strategic alliances with the public and private sectors.

Key components include the EnerGuide fuel-consumption label for vehicles and the annual *Fuel Consumption Guide*, which provide fuel consumption data for new light-duty vehicles; the Idle-Free Campaign, which seeks to curb vehicle idling; and the Auto$mart Student Driving Kit, which helps driver instructors teach fuel-efficient driving to novice drivers. Recently the initiative started the development of a national public awareness and education campaign, in collaboration with the tire manufacturing industry, to encourage Canadian motorists to adopt good tire maintenance and inflation practices.

Key 2002–2003 Achievements

- 150 new driver instructors were recruited this year and are now using the Auto$mart Student Driving Kit. More than 800 000 novice drivers have been exposed to fuel-efficient driving training to date.
- The Idle-Free Awareness Campaign was successfully implemented in two cities and is currently being extended to eight others.
- NRCan signed an agreement with the Rubber Association of Canada (representing tire manufacturers) to develop and deliver a national public awareness and education campaign on tire maintenance and inflation. Transport Canada and Environment Canada have also joined the campaign.

For more information: oee.nrcan.gc.ca/vehicles/

FIGURE 7-6

Vehicle Fuel Efficiency Awareness

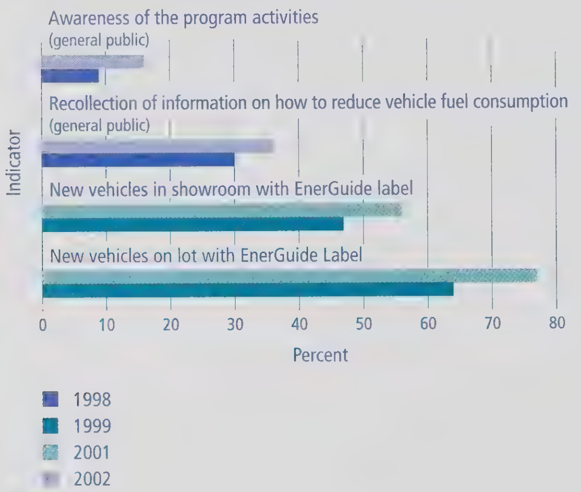


FIGURE 7-7

Number of New Drivers Educated Using the Auto$mart Student Driving Kit

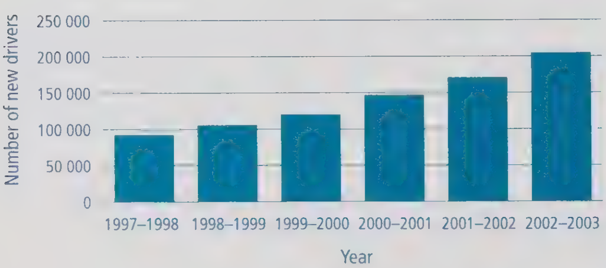


FIGURE 7-8

EnerGuide Label for New Vehicles

Vehicles: Fleet Vehicles

Objective: To improve the fuel efficiency and reduce the GHG emissions in commercial road transportation fleet operations and all other non-Government of Canada vehicle fleets.

Fleet Vehicles provides information materials, workshops, technical demonstrations, driver training programs and special projects, such as the Truck Stop Idle-Free/Quiet Zone Campaign, to help fleet operators assess and pursue opportunities to increase energy efficiency in their operations. NRCan delivers the initiative in partnership with fleet and industry associations and other levels of government.

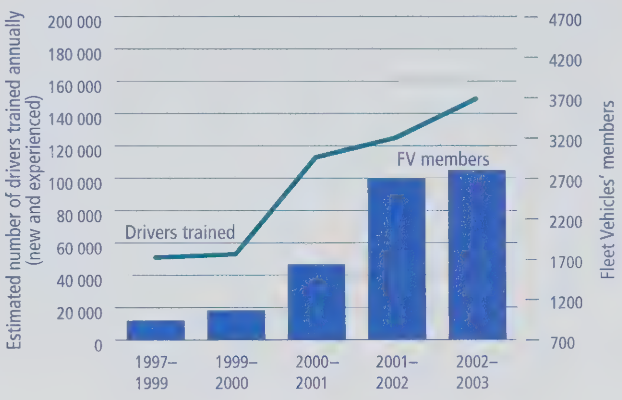
Key 2002–2003 Achievements

- The SmartDriver Initiative trained more than 149 000 new and experienced drivers and introduced over 1000 new instructors to the Fleet Vehicles initiative.
- To date, the Fleet Vehicles initiative has registered over 2800 members, representing more than 409 000 commercial vehicles.
- SmartDriver for Forestry Trucks was developed and launched in partnership with the Forest Engineering Research Institute of Canada.
- The Truck Stop Idle-Free/Quiet Zone Campaign was successfully piloted, with 14 truck stops participating nation-wide.

For more information:
fleetsmart.nrcan.gc.ca/

FIGURE 7-9

Drivers Trained and Participation in the Fleet Vehicles Initiative



Transportation Research and Development: Canadian Lightweight Materials Research Initiative (CliMRI)

Objective: To develop low-density, high-strength, lightweight materials to achieve weight reductions in ground transportation vehicles.

Outcomes of this government-industry-university research initiative are two-fold: reducing GHG emissions through improved vehicle efficiency and improving the competitive performance of Canadian companies and associated part suppliers in the primary metals, automotive, truck, bus and rail-car manufacturing industries. CLiMRI also funds projects that focus on the manufacturing processes of the materials.

Key 2002–2003 Achievements

- CANMET Materials Technology Laboratory (CANMET-MTL) developed a pilot-scale process for seam-welding aluminum tubes. These tubes are used in hydroforming, a metal-shaping process used in the automotive industry. This advancement in tube hydroforming broadens the applicability of this manufacturing process, leading to greater use of lightweight metals in vehicles. Six papers, two reports and seven presentations were made in this area.
- CANMET-MTL optimized the heat treatment process for alloy A356, commonly used in the automotive industry. In addition to improving the mechanical properties, this process minimizes GHG emissions and reduces energy consumption by one third. Two foundries have already adopted the shorter heat-treatment cycle in their production.
- In the creation of cast automotive parts, "test bars" are poured for quality control. CANMET-MTL has developed a new test-bar mould that can better identify mechanical properties in the actual casting, enabling foundries to consistently produce premium-quality castings and reduce scrap.
- CANMET-MTL also developed CANMET Property Predictive Software, based on an artificial intelligence model that can predict mechanical properties of automotive aluminum alloys derived from chemistry, heat treatment and casting variables.

For more information:
climri.nrcan.gc.ca/default_e.htm

Transportation Research and Development: Fuel-Cell-Powered Mining Vehicles

Objective: To develop the technology to replace diesel power by hydrogen fuel cell power in underground mining vehicles.

NRCan has taken a leadership role in this North American consortium. If this initiative is successful, Canada stands poised to capture world markets for applied fuel cell technology in mining – a clear example of the link between innovation and economic growth.

The application of fuel cell technology to underground mining by retrofitting diesel-powered vehicles would provide several benefits. These include eliminating underground diesel emissions and reducing heat and noise, thus improving the work environment for underground miners; reducing a significant portion of carbon dioxide emissions (1 million tonnes per year), thus giving the mining industry an opportunity to contribute to Kyoto Protocol emissions targets; and decreasing operating costs by lowering mine ventilation needs by more than 35 percent (ventilation is responsible for 40 percent of the electrical consumption in an underground mine) and by significantly improving vehicle productivity (hydrogen-fuel-cell power systems are twice as efficient in delivering power as conventional diesel equipment).

The prototype locomotive propelled with hydrogen fuel cells, the only example of its kind, has been undergoing surface testing by NRCan since the beginning of 2002, most recently at its experimental mine in Val-d'Or, Quebec. NRCan also provided the expertise of scientists and engineers who integrated the fuel cell with the locomotive and its control systems and conducted surface testing. The locomotive is now at the Experimental Mine at Val-d'Or undergoing long-term reliability testing of the fuel cell. It is expected that many different types of vehicles, including underground diesel loaders – the mainstay of metal mine production – will eventually use this technology, and pilot projects are now underway in Canada, the United States and other countries.

Key 2002–2003 Achievements

- The fuel cell locomotive was subjected to various refuelling tests in order to quantify the power-consumption curve for mine locomotive power plants and the hydrogen consumption rate, cost and electrolysis plant refuelling aspects.
- Mine regulatory issues have been addressed to have fuel cells in operation in underground Canadian mines.
- A ground-breaking Canadian mine cost-benefit study was carried out to quantify operational cost savings of using fuel cell mine vehicles versus diesel mine vehicles (significant electrical consumption and operating cost reductions are possible) as well as capital costs (ventilation equipment savings are possible, but initial fuel cell costs are still high).
- The fuel cell underground mine loader (main production vehicle) project has been initiated and partners assembled. Initial design issues for the fuel cell mine loader have been addressed.
- A series of reports were issued on the following projects: suitability of fuel cells for underground use, locomotive power plant design, locomotive performance, locomotive refuelling, mine vehicles duty cycles and fuel cell power plant requirements (a cost-benefit study). The technology transfer has been made through a special session of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) 2003 Annual General Meeting.
- Initial discussions held to commercialize Canadian-built underground locomotives with Canadian fuel cell technology for the international road-tunnelling excavation market.

For more information:
www.nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mines/mines-e.htm

Alternative Transportation Fuels: Vehicle Fuels

a) Future Fuels Initiative (National Biomass Ethanol Program)

Objective: To increase Canada's fuel ethanol production and use in the transportation sector.

This initiative aims to increase the supply and use of fuel ethanol produced from biomass such as plant fibre and corn, wheat and other grains. The major component of the Initiative is the renewal of the National Biomass Ethanol Program, a contingent loan guarantee program intended to reduce the financial risk of new plant construction. Other activities include public education, economic and market analyses, research of standards and harmonization of policies where possible.

Key 2002–2003 Achievements

- Several plant proposals have advanced over the course of the year.
- Two provinces announced plans to introduce legislation to require ethanol in their gasoline.
- The Council of Energy Ministers Working Group on Ethanol and Biofuels has facilitated joint federal, provincial and territorial information sharing, research and public awareness.

For more information:
oee.nrcan.gc.ca/vehiclefuels

b) Canadian Transportation Fuel Cell Alliance

Objective: To evaluate different fuelling options for fuel cell vehicles, develop the supporting framework for the fuelling infrastructure and demonstrate their GHG emissions reductions.

The Canadian Transportation Fuel Cell Alliance (CTFCA) is a private-public sector partnership initiative made up of technology developers, fuel providers, auto manufacturers, federal and provincial government officials, academia and non-governmental organization representatives. The CTFCA demonstrates and assesses the technical feasibility and the economic and emissions implications of hydrogen refuelling options for fuel cell vehicles. The initiative will also develop a supporting framework for hydrogen refuelling through standards, codes, certification and training.

Key 2002–2003 Achievements

- Two demonstration projects were funded under this initiative. These include supporting the development of a hydrogen refuelling apparatus for a natural-gas reformer and demonstrating an electrolysis technology for a mobile hydrogen-fuelling station.
- Studies were completed on fuel pathways and GHGs, with six pathways analyzed.

For more information:
nrcan.gc.ca/es/etb/ctfca/index_e.html

c) Natural Gas Vehicles Initiative

Objective: To promote the development and use of natural gas vehicles in Canada.

The Natural Gas Vehicles Initiative targets the natural gas industry in regions of Canada serviced by Alberta natural gas. The Initiative provides financial contributions for each factory-built natural gas vehicle, for dealers to sell new factory-built natural gas vehicles and for road vehicles converted to use natural gas. The Initiative also funds marketing and awareness activities and co-funds R&D.

Key 2002–2003 Achievements

- 23 new qualified units were sold and 17 units converted.
- One new site for natural gas fuelling was opened.

For more information:
oee.nrcan.gc.ca/vehiclefuels

Transportation Technologies:
Transportation Energy Technologies Program

Objective: In partnership with industry, to develop and deploy leading-edge transportation technologies that minimize environmental impacts, increase the potential for job and economic growth and extend the lifespan of Canada's energy resource base.

Program staff work with stakeholders in the domestic and international transportation industries, including original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the U.S. Department of Energy and the International Energy Agency.

- Over the last 15 years, work in partnership with Canada's fuel cell industry has established Canada as a world leader in fuel cell and refuelling technologies; for example, the world's first hydrogen fuel cell bus was demonstrated in Canada.
- Since the 1980s, the program has supported student vehicle challenges, bringing university and college students from across North America together with automotive manufacturers to modify existing vehicles to run a variety of alternative fuels.
- The program has supported the development of alternative transportation fuel technologies, for example, for natural gas and propane vehicles, which has led to a Canadian industry that is now exporting commercial products.

Key 2002–2003 Achievements

- Organization and sponsorship of world-class conferences, including the 2002 World Hydrogen Energy Conference in Montréal, Quebec; the Canadian Electric Vehicle Conference; and the 2002 Windsor Workshop on Transportation Technology.
- Initiation of a project with Hydrogenics Corporation to develop a hybrid fuel cell bus that incorporates ultra-capacitors.
- The first public E-85 fuelling station in Canada was opened in Ottawa, Ontario, to dispense a mix of 85 percent ethanol and 15 percent gasoline for automobiles.
- Signing of an agreement with Dynetek Industries Ltd. of Calgary, Alberta, to develop lightweight hydrogen-storage cylinders at 700-bar (10 000-psi) pressure.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_tet_e.html

Chapter 8: Renewable Energy

Introduction

Renewable energy sources are those that produce electricity or thermal energy without depleting resources. Renewable energy includes solar, wind, water, earth and bioenergy, including energy from waste.

Natural Resources Canada (NRCan) delivers several initiatives to encourage the development and use of emerging renewable energy sources and technologies. However, these initiatives do not apply to the following renewable energy resources:

- large-scale hydro-electricity, a well-established renewable energy source; and
- ethanol fuel production from agricultural feedstocks, which is covered under Agriculture and Agri-Food Canada programs.

Each renewable energy source depends on one or more energy production technologies, with their own level of economic attractiveness. Some technologies are mature and well recognized (e.g. hydro-electricity), others are emerging in the marketplace, and many are in the laboratory stage but offer promise for the long term. Renewable energy sources compete in many markets, including those for electricity, mechanical power, thermal energy (process heat, space heating and cooling and water heating and cooling) and transportation fuels (see Table 8-1).

Renewable Energy Use

In 2000, renewable energy generation capacity from renewable sources accounted for 62 percent of total Canadian electricity capacity (see Table 8-2). Most of the renewable energy used in Canada comes from either hydro-electricity or thermal energy from biomass such as wood-waste sources.

TABLE 8-1

Renewable Energy Markets and Technologies Used in Canada

Electricity	*Thermal Energy*
Hydro-electricity	Biomass (e.g. roundwood, pellets, wood chips)
Tidal power	Ground-source heat pumps (e.g. earth energy)
Biomass (e.g. wood waste)	Solar air-heating systems
Biogas (e.g. methane from landfill sites)	Solar hot-water systems
Wind turbines	
Photovoltaic systems	
Mechanical Power	*Transportation*
Wind water pumps	Ethanol from biomass

TABLE 8-2

Electricity Generation Capacity From Renewable Sources (Includes Hydro)

Year	*Renewable electricity generation capacity (MW)*	*% of total capacity*
2000	68 986	62
1999	68 686	62
1998	68 340	62
1997	68 202	61
1996	67 101	59
1995	66 542	57
1994	63 175	56
1993	63 114	56
1992	62 895	58
1991	61 116	58
1990	59 557	58

Hydro-Electricity

Hydraulic power is a renewable energy based on the water cycle – evaporation, precipitation and flow of water toward the ocean. Canada has abundant water resources, and its geography provides many opportunities to produce low-cost energy. Tapping the energy from moving water has played an important role in the economic and social development of Canada for the past three centuries.

In 2002, hydro power accounted for about 60 percent of total electricity generation. Small-scale hydro-electric projects, with a capacity of 20 megawatts or less, constitute about 4 percent of Canada's electricity-generating capacity. Small-scale hydro has good potential for increased production.

Biomass

Bioenergy is a renewable source of energy derived from organic substances known as biomass. Biomass is supplied by agricultural wastes, such as chaff, straw, grain screenings, husks and shells, food-processing residues and methane. Other biomass supplies include animal litter and manure, landfill gas methane, urban wastes to be incinerated and sewage for biogas. Bioenergy contributes about 6 percent of Canada's primary energy, mostly for industrial process heat, electricity generation and residential space heating. Corn and other agricultural products are also used to generate ethanol and biodiesels for the transportation market.

Bioenergy production represents Canada's second largest renewable energy source. Most bioenergy is produced from organic refuse and used with the facilities in which the energy conversion takes place. The pulp and paper industry produces and uses most of Canada's bioenergy. Industrially produced heat and electricity, independent power producers' electricity, electricity from urban wastes and residential wood heat are all considered commonplace in Canada's energy mix.

Home heating with wood usually takes the form of stand-alone wood stoves, water or forced-air wood furnaces, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters. About 3 million Canadian households use wood for home heating. Canadians usually prefer roundwood, but alternatives include wood chips and pellets.

Earth Energy

As a result of the sun heating the surface of the planet, the temperature of the earth that is one or two metres below the surface remains fairly constant – between 5 and 10°C. This is warmer than outside air during the winter and cooler than outside air during the middle of summer. A ground-source heat pump takes advantage of this temperature difference by using the earth or the ground water as a source of heat in the winter and as a "sink" for heat removed from indoor air in the summer. For this reason, ground-source heat pumps are known as earth energy systems (EESs).

During winter, EES installations remove heat from the earth using a liquid, typically an antifreeze solution, that circulates within an underground loop. It then upgrades the heat with a conventional heat pump and transfers it to indoor space or the water heating system. During summer, the system reverses this process to operate as an air conditioner. EES installations supply less than 1 percent of the market for space and water heating and cooling in Canada.

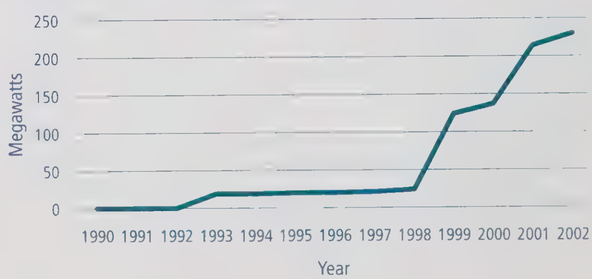
Wind Energy

Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada has a large wind resource potential because of its large size and northern location. A 1992 NRCan study estimated the technical wind energy potential in Canada at about 28 000 megawatts. If developed, this could supply 11 percent of total Canadian electricity consumption. In 2002, wind energy accounted for less that 1 percent of Canada's total electricity generation.

Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie Provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses (see Figure 8-1).

FIGURE 8-1

Canadian Wind Power Capacity, 1990 to 2002



Solar Energy

Three main technologies use energy from the sun:

- passive solar technologies mean that buildings are designed and located to maximize their reception of solar energy;
- active solar thermal systems convert solar radiation into thermal energy for heating air or water in residential, commercial and industrial applications; and
- solar electric (photovoltaic) systems use solar radiation to produce electricity.

During the 1990s, NRCan assisted a Canadian company in developing a perforated solar absorber to preheat ventilation air and reduce a building's fuel requirements for space heating. This technology is more cost-effective than conventional solar air heating technologies and is gaining acceptance in Canada and abroad. Systems have been installed on industrial, institutional and commercial buildings throughout Canada.

The installed photovoltaic power capacity in 2002 was 10 megawatts, with an estimated annual production of 8 gigawatt hours of electricity. The bulk of this capacity is either "off grid" (not connected to an electrical transmission system), where the price of photovoltaics is competitive with conventional stand-alone power systems, or an extension of a grid to a given location.

Typical applications include telecommunications systems, water pumping and purification, remote monitoring and control, remote residences, coast-guard lighting and beacon systems, and numerous consumer applications, such as hand-held calculators. The Canadian Coast Guard is the largest individual user of photovoltaic systems in Canada, with an estimated 7000 navigational buoys, beacons and lighthouses.

Canada has about 100 grid-connected photovoltaic systems installed on residential rooftops and buildings, providing on-site power with a combined capacity of 368 kilowatts. Significant reduction in equipment costs were observed, with Canadian photovoltaic panel prices decreasing to $7.14 per watt in 2002 compared with $11.09 per watt in 1999 (a reduction of 14 percent per year).

NRCan delivers several initiatives to increase the use of small-scale renewable energy in Canada. The following is the array of NRCan renewable energy programs.

Renewable Energy Programs: ENergy from the FORest (ENFOR)

Objective: To improve the understanding of the role of biomass production for energy and to improve biomass productivity from natural forests and from plantations growing willow and poplar.

ENFOR, managed by the Canadian Forest Service (CFS) of NRCan, undertakes research and development (R&D) on the production and harvesting of forest biomass for energy through the private sector, universities or CFS research centres. ENFOR also investigates the broader environmental effects of harvesting from forests and short-rotation plantation culture, focusing on sustaining forest productivity and improving the sequestration and storage of atmospheric carbon in forest ecosystems. ENFOR also supports research on information systems to determine the quantity and quality of biomass in Canadian forests.

Key 2002–2003 Achievements

- Several species/varieties of willow and poplar have been assessed for production in Quebec, Ontario and the Prairie Provinces. Plantation establishment has been successful throughout much of Canada, and industry is now engaged in the large-scale planting of fast-growing poplars.
- The CFS, acting as the Canadian lead for the International Energy Agency (IEA) Bioenergy Agreement, continued its collaboration, with a series of workshops, seminars and publications.
- Publications from the IEA: *Sustainable Production of Woody Biomass for Energy* describes the activities of the four forest-related tasks (including ENFOR) in the agreement and how they link to sustainability issues. *Socio-economic Drivers in Implementing Bioenergy Projects: An Overview* describes the activities and goals of Task 29: Socio-Economic Aspects of Bioenergy Systems.
- Major successes include the Forest Biomass Inventory of Canada; the modelling of whole-tree harvesting/nutrient cycling; the Carbon Budget Model of the Canadian Forest Sector; and the development and testing of species, clones and production technologies for energy plantations.
- Publication: Hall, J. Peter, 2002. *Sustainability of Renewable Biomass for the Production of Energy*, presented at the GLOBE 2002 conference in Vancouver, British Columbia.

For more information:
nrcan.gc.ca/cfs-scf/science/resrch/bioenergy/

Renewable Energy Programs: Initiative to Purchase Electricity From Emerging Renewable Energy Sources

Objective: To purchase electricity from emerging renewable energy sources (ERES) that are certified by a third party as having low environmental impact, with the objective of reducing greenhouse gas (GHG) and other air pollution emissions associated with federal electricity consumption.

Between 1998 and 2001, NRCan entered into three pilot projects to purchase electricity from ERES for federal facilities in Alberta, Saskatchewan and Prince Edward Island. NRCan has pledged to purchase 20 percent of its electricity from ERES by 2010.

Key 2002–2003 Achievements

- The Government of Canada received its first full year of electricity from ERES in Saskatchewan and Prince Edward Island. An estimated 32.4 gigawatt hours (GWh) and 13 GWh were delivered to the grid in Saskatchewan and Prince Edward Island, respectively. This resulted in estimated emissions reductions of 29 000 tonnes of GHGs in Saskatchewan and 11 000 tonnes in Prince Edward Island.
- NRCan continues to receive 10 000 GWh of electricity from ENMAX Corporation in Alberta. This purchase results in GHG emissions reductions of about 9000 tonnes annually.
- The Prince Edward Island and Saskatchewan governments are purchasing electricity from ERES for their facilities.
- SaskPower constructed a second wind farm in Saskatchewan in fall 2002. This wind farm provides electricity for SaskPower facilities, provincial government facilities and SaskPower's green power purchases.
- The governments of Ontario and Alberta committed to purchasing electricity from renewable sources. Ontario will target 20 percent of its electricity use, and Alberta will enter into long-term contracts for 210 GWh annually.

For more information:
nrcan.gc.ca/redi

Renewable Energy Programs: Photovoltaic and Hybrid Systems Program

Objective: To support the development and application of solar photovoltaic (PV) technologies in Canada.

The Photovoltaic and Hybrid Systems Program contributes to increasing the use of PV energy technologies in Canada by developing technologies and removing barriers and by facilitating the development of a Canadian-based globally competitive PV industry. It also contributes to the development of policies and programs.

In collaboration with Canadian industry and universities as well as international energy research organizations, the CANMET Energy Technology Centre – Varennes undertakes R&D activities and fosters information exchanges that will encourage the adoption of PV-hybrid systems; validates the performance and safety of utility-interactive DC to AC inverters; supports the development of building-integrated PV technologies and systems; and facilitates the development and adoption of harmonized standards and codes for PV and distributed generation systems in Canada.

Key 2002–2003 Achievements

- Signed an agreement with the Yukon Energy Solution Centre and the Arctic Energy Alliance to collaborate in the assessment and promotion of renewable energy in off-grid residences.
- Completed the preparation of the national Interconnection Guideline for small decentralized energy production, forging a way for alternative energy sources to become part of the electricity supply mix in Canada.

For more information:
www.micropower-connect.org

- Co-hosted a workshop, with the Institute of Electrical and Electronics Engineers, on the grid connection of inverter-based distributed generators to identify the challenges and R&D needs of the industry in Canada.
- Co-hosted a workshop, with the Royal Architectural Institute of Canada and the University of British Columbia, that will contribute to mainstreaming building-integrated technology in Canada.

For more information:
cetc-varennes.nrcan.gc.ca/en/er_re.html

Renewable Energy Programs: Renewable Energy Capacity-Building Program (RECAP)

Objective: To build the capacity of planners, decision-makers and industry to implement renewable energy and energy efficiency projects.

The Program works to meet its objective by developing decision-making tools that reduce the cost of pre-feasibility studies, training people to better analyse the technical and financial viability of possible projects, disseminating knowledge to help people make better decisions and connecting buyers and sellers to help implement projects and expand markets.

Key 2002–2003 Achievements

- RECAP has developed and promoted a new RETScreen® International Renewable Energy Decision Support Centre Web site and CD. Available on the Web site and CD are the RETScreen® International Renewable Energy Project Analysis Software, the new RETScreen® Engineering and Cases Electronic Textbook, the new Renewable Energy Project Analysis Course and a new Interactive Marketplace.
- A RETScreen® GHG Baseline Project Analysis Software Model (in collaboration with the Prototype Carbon Fund) and a RETScreen® Combined Heat and Power Project Analysis Software Model are also under development.
- RECAP, in collaboration with the Renewable Energy Deployment Initiative and the Office of Energy Efficiency, has developed, promoted and delivered a one-day Renewable Energy Training Seminar.
- Within the last two years, more than 1200 people were trained in Canada at 47 seminars. The trainees included planners, decision-makers and contractors from Aboriginal and northern communities, and federal and municipal facilities, as well as industry sellers, planners, designers and installers.
- RECAP has provided post-training technical support and project facilitation services. Additional Canadian project facilitation services supported by the RECAP team were 4 Aboriginal and northern energy centres, 160 Aboriginal and northern community studies, 40 federal facility studies and 71 municipal facility studies.
- RECAP has developed, promoted and delivered a new two-day RETScreen® International Trainer Certification Workshop.
- The International network of certified RETScreen® trainers is now being established, with 76 people trained so far.

For more information:
cetc-varennes.nrcan.gc.ca/en/er_re/rcer_recb.html
or
retscreen.net

Renewable Energy Programs:
Renewable Energy Deployment Initiative (REDI)

Objective: To stimulate the demand for renewable energy systems by helping the supply industry in its marketing and infrastructure development efforts, including the provision of financial incentives.

REDI targets four systems: solar water-heating, solar air-heating, earth energy, and high-efficiency, low-emissions biomass combustion. REDI promotes these systems in the business, federal and non-business markets through three means: a financial incentive, market assessment and information and awareness.

Key 2002–2003 Achievements

- $968,452 in REDI financial incentives was distributed among 50 projects valued at $5 million; the projects were completed in 2002–2003.
- Gathered data on solar thermal collector areas installed in Canada from 1995 to 2001. A total of 170 432 square metres, which saved 250 terajoules annually, was recorded to the IEA for its annual survey of solar thermal market development.
- Released the report entitled *Survey to Gauge Awareness, Knowledge and Interest Levels of Canadians Toward Solar Domestic Hot Water Systems*.
- Contributed to the development of the Canadian Bioenergy Association, which was launched in October 2002 as the first Canadian association for the development of bioenergy.
- Initiated earth energy projects with the Canada Customs and Revenue Agency and initiated the communication strategies to increase the deployment of renewable energy technologies in the federal sector.
- In collaboration with the Canadian Electricity Association and the Geothermal Heat Pump Consortium, helped to establish the Canadian GeoExchange Coalition, which is comprised of energy utilities and industry stakeholders consolidating efforts to promote earth energy in Canada.
- In collaboration with industry partners, produced several new publications on renewable energy, including the following:
  - *Commercial Earth Energy Systems: A Buyer's Guide*
  - *Discover the Production and Uses of Biogas*
  - *Discover the Benefits of Residential Wood Heating*
  - Two solar water-heating case studies
  - *Earth Energy in Our Community* (available on DVD)
  - *REDI Project Profile No. 1 – Textile Manufacturing Industry*

For more information:
nrcan.gc.ca/redi

TABLE 8-3

REDI for Business Projects Completed, 1998 to 2002

	Number of projects	*Estimated GHG reduction (tonnes CO_2/yr.)*	*Cost of system*	*NRCan contribution*
1998–1999	10	2 909.0	$1,428,063	$176,392
1999–2000	9	260.8	$479,633	$119,910
2000–2001	24	5 825.4	$1,849,918	$327,078
2001–2002	51	23 476.0	$6,708,120	$1,362,399
2002–2003	50	7 649.9	$5,077,937	$968,452
Total	**144**	**40 121.1**	**$15,543,671**	**$2,954,231**

Renewable Energy Programs: Renewable Energy Technologies (RET) Program

Objective: To support efforts by Canadian industry to develop renewable energy technologies.

Technologies supported include bioenergy (combustion, biochemical conversion of biomass to ethanol, thermochemical conversion of biomass to bio-oil and biogas, and biomass preparation and handling), small hydro projects (less than 20 megawatts), active solar applications and wind energy. Activities are directed toward improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users and helping industry commercialize its products in domestic and foreign markets.

With ongoing support from NRCan and other federal departments, Iogen Corporation is continuing on a successful path to full-scale commercialization of its process for producing fuel ethanol from agricultural residues, such as straw. The company's pre-commercial demonstration plant in Ottawa, Ontario, is processing 25 tonnes per week of wheat straw into fermentable sugar. This major achievement affirms Iogen's position as the world leader in developing this complex technology.

Key 2002–2003 Achievements

- Suncor Energy Products Inc., in partnership with NRCan's RET and REDI programs, launched the first solar car wash in Canada to use solar pool-heating technology at Suncor's Sunoco gas station in Markham, Ontario.
- Energy Ottawa, with the support of the Government of Canada, installed newly developed hydro-turbine technology at its small hydro-generating site, increasing the efficiency of the plant by 30 percent.
- Tembec, in partnership with the Government of Canada, installed and began operating trials on a novel system to produce combustible biogas from pulp mill sludges.
- The BIOX Corporation, with support from NRCan, successfully scaled up its innovative biodiesel production technology from an experimental-sized unit to a one-million-litre pilot plant.

For more information:
canren.gc.ca

Renewable Energy Programs: Wind Power Production Incentive (WPPI)

Objective: The WPPI is a 15-year, $260-million program to support the installation of 1000 megawatts of new wind energy capacity by March 31, 2007.

The WPPI encourages electric utilities, independent power producers and other stakeholders to gain experience in wind power, an emerging energy source. The incentive is about $0.01 per kilowatt hour of production and represents about half of the current cost of the premium charged for wind energy in Canada for facilities where good wind resources exist. Eligible recipients can receive the incentive for 10 years.

By displacing other electricity sources and through continued momentum, wind-power capacity installed under the WPPI is projected to reduce GHG emissions by three megatonnes annually by 2010.

Key 2002–2003 Achievements

- Received 87 letters of interest for 3600 megawatts of wind-energy projects from developers, utilities and businesses. By the end of the fiscal year, five projects were completed or under construction, for a total new capacity of about 93 megawatts. Two projects were in Ontario (9.75 megawatts), two in Alberta (75.2 megawatts) and one in Saskatchewan (5.94 megawatts), resulting in a commitment of more than $40 million of incentive payments over 10 years.

For more information:
canren.gc.ca/wppi

Chapter 9: Federal House in Order

Introduction

The Government of Canada is the country's largest single enterprise. It is working to get its own house in order by setting a target of 31 percent reduction in greenhouse gas (GHG) emissions from its own operations by 2010.

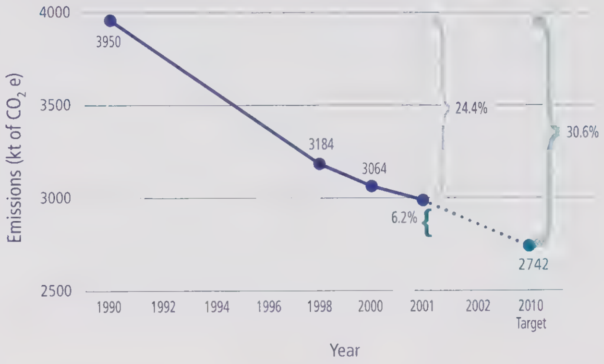
Since 1990, through building retrofits, better fleet management, strategic "green power" purchases and the downsizing of operations, the Government of Canada has already achieved a 24 percent emissions reduction. The Government of Canada will reduce its emissions by a further 12 percent by 2010.

The Government of Canada will achieve its goal by additional building retrofits, fuel switching and increased use of renewable energy within government operations. Moreover, the Government of Canada can help to "create the market" for certain new technologies on the verge of becoming viable. Key departments, which are responsible for 95 percent of government GHG emissions, have been assigned specific targets and must report annually on their progress.

The task of target sharing has been undertaken by means of a three-year action plan and entails assigning specific targets to the 11 key departments. Natural Resources Canada (NRCan) is taking a lead role in managing this task and in providing the services to departments and agencies that will help them achieve their targets. The Leadership Challenge encourages the reduction of all federal emissions by engaging the active participation of the departments, agencies and Crown corporations that were not designated with a target.

FIGURE 9-1

GHG Emissions Reductions From Federal Operations



The Federal House in Order initiative consists of various complementary activities – including GHG inventory and tracking, purchases of emerging renewable electricity or green power and efforts to reduce "outside emissions" (a pilot project for transit passes through payroll deduction for federal employees was launched October 2002). It also has three supporting programs:

- Federal Buildings Initiative;
- Federal Industrial Boiler Program; and
- Federal Vehicles Initiative.

Federal Buildings Initiative (FBI)

Objective: To assist Government of Canada organizations to implement energy efficiency improvements, leading to reduced energy use, GHG emissions and operating costs.

The FBI facilitates comprehensive energy efficiency upgrades and building retrofits for departments, agencies and Crown corporations of the Government of Canada through private-public partnerships with energy management firms. The FBI provides a range of products and services, including advice and consultation on organization readiness and project applicability; lists of energy management firms qualified to implement projects; project-financing options through guaranteed savings; a national network for energy management training; model energy performance contracts; and employee awareness training.

Key 2002–2003 Achievements

- $1-million worth of incremental energy savings were achieved.
- Energy intensity improved by 20 percent, and GHG emissions reductions of 15–20 percent were achieved.

For more information:
oee.nrcan.gc.ca/fbi/home_page.cfm

Federal Industrial Boiler Program (FIBP)

Objective: To provide technical and project management services to assist federal facilities implement energy reduction projects.

The FIBP's extensive experience in building energy systems and access to the engineering and scientific network within the CANMET Energy Technology Centre ensures that environmentally responsible technologies are considered when federal government clients replace or modify their space heating and cooling systems. Since its inception in 1991, the FIBP has worked with many departments, including Agriculture and Agri-Food Canada, Correctional Service Canada (CSC), National Defence, Environment Canada, and the Department of Foreign Affairs and International Trade (DFAIT), to reduce their energy costs. Under the FIBP, GHG emissions are reduced by an average of 4.7 kilotonnes per year.

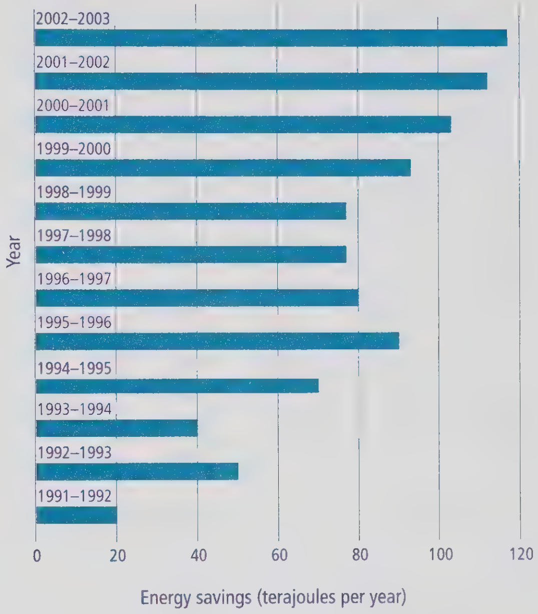
Key 2002–2003 Achievements

- Conducted a study for Environment Canada to compare the operating costs, environmental emissions and GHG production from heating plants operating on No. 6 fuel oil with those operating on No. 2 fuel oil.
- Worked with DFAIT at its embassy in New Delhi, India, to implement a cogeneration-based site power generation system.
- Participated in CSC's sustainable development strategy by inspecting heating systems in federal penitentiaries across the country to recommend options for improving energy efficiency and reducing operating costs and GHG emissions.
- Reviewed operations and systems at Communications Research Centre Canada (CRC), an agency of Industry Canada. The CRC is entering into a second energy management services company contract to implement FIBP report recommendations.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/research_programs_fibp_e.html

FIGURE 9-2

Annual Energy Savings From the FIBP, 1991–1992 to 2002–2003



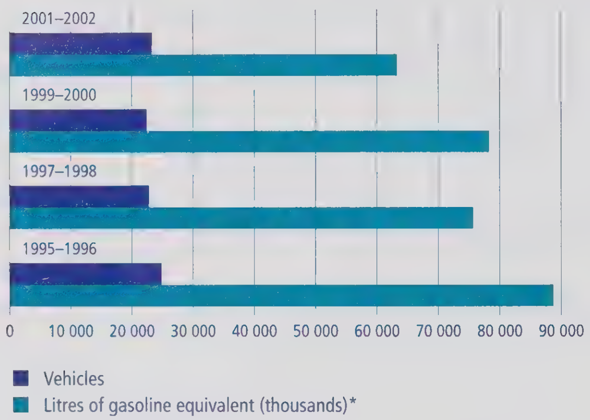
Federal Vehicles Initiative

Objective: To assist federal government departments increase the energy efficiency of their motor vehicle fleets and reduce the environmental impact of federal vehicle operations and to promote the *Alternative Fuels Act* within the federal fleet.

The Initiative provides fleet managers with an assessment of fleets as well as technical advice and encouragement on acquiring and using alternative transportation fuels (ATFs). Four departments participate in planning and reporting on the Initiative: Treasury Board of Canada Secretariat, NRCan, Environment Canada and Public Works and Government Services Canada.

FIGURE 9-3

Federal Fleet Size and Fuel Consumption, 1995–1996 to 2001–2002



*Gasoline equivalent is computed by dividing the lower heating value of the alternative fuel by the lower heating value of gasoline and multiplying this result by the alternative fuel consumption value.

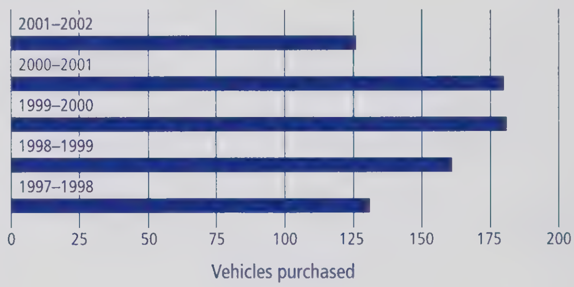
Key 2002–2003 Achievements

- In 2002–2003, over 200 vehicles used E-85 (a fuel consisting of 85 percent ethanol) regularly. This represents about 1 percent of the federal vehicle fleet and is more than double the number in the preceding year.
- Over 130 hybrid gasoline-electric vehicles were operating in the federal vehicle fleet.
- Over 10 percent of the newly acquired vehicles could operate on alternative fuels, an increase from the 3 percent of the preceding year.

For more information:
oee.nrcan.gc.ca/greening/home.cfm

FIGURE 9-4

Annual Purchases of ATF Vehicles for the Federal Fleet, 1997–1998 to 2001–2002



Chapter 10: Intergovernmental Cooperation

Introduction

This chapter describes Natural Resources Canada's (NRCan's) intergovernmental cooperation with respect to efficiency and alternative energy (EAE) during the reporting period at three levels: municipal, provincial/territorial and international. Other examples of intergovernmental cooperation are set out in previous chapters in the Key Achievements sections of specific EAE program initiatives.

Federal-Provincial and Federal-Territorial Cooperation

Provincial and territorial governments delivered a substantial number of EAE programs during the reporting period to reduce energy costs, increase competitiveness, improve air quality and generate economic and trade opportunities. Coordination between the federal and provincial/territorial levels is essential to avoid duplication and ensure efficient program delivery. During the reporting period, the governments cooperated at the general level and at the level of specific program initiatives.

General Cooperation

Cooperation Agreements

- NRCan had a Letter of Cooperation (LOC) on EAE with the Agence de l'efficacité énergétique du Québec during the reporting period. The LOC ensures an efficient consultation and exchange of information between the two governments, and it helps coordinating EAE activities in the province and creating opportunities for joint projects. The management committee established under the LOC met twice a year during the period to review policy and program developments, progress on joint program initiatives and areas for further cooperation.
- The LOC played a considerable role in facilitating the conduct of three activities in particular:
  - the management of the licensing agreement for EnerGuide for Houses (which is delivered in Quebec by the Agence de l'efficacité énergétique);
  - the conclusion of a contribution agreement between NRCan's Office of Energy Efficiency (OEE) and the Agence de l'efficacité énergétique under the Commercial Building Incentive Program regarding projects submitted to NRCan by public organizations in Quebec. The cooperation framework that was agreed upon in February 2000 is now being applied to other NRCan energy sector programs aimed at the public sector in Quebec; and
  - the management of the agreement between NRCan (CANMET Energy Technology Centre – Varennes, Quebec) and the Agence de l'efficacité énergétique relating to the Programme d'intervention en réfrigération dans les arénas du Québec. Among activities, an important study was completed to evaluate the potential energy savings and greenhouse gas emissions reduction in Quebec's arenas.
- Another LOC on energy efficiency and renewable energy was signed in 2001 between the Government of Canada and the Government of Yukon with similar objectives, i.e. facilitating information exchange and creating opportunities for joint projects in Yukon Territory. Close cooperation between these two governments has also resulted in the creation of the Canada–Yukon Energy Solutions Centre in Whitehorse, Yukon Territory, which started its operations in December 2000. The Centre provides access to relevant technical services for the Yukon population, undertakes outreach and public education activities and delivers assigned energy efficiency and renewable energy programs in Yukon Territory.

The Government of Canada also contributed to the Arctic Energy Alliance in Whitehorse, Northwest Territories, to facilitate opportunities for energy

EAE projects in the Northwest Territories. The Arctic Energy Alliance promotes EAE programs and delivers EnerGuide for Existing Houses in the Northwest Territories.

National Advisory Council on Energy Efficiency (NACEE)

- NRCan created NACEE in April 1998 to advise and guide the OEE on the most effective way to achieve its mission. During 2002–2003, NACEE members included representatives from across Canada who had the opportunity to comment on the OEE's business plan and programs.

Cooperation at the Program Level

R-2000 Standard

- In 2002–2003, the R-2000 Standard was delivered in seven provinces (Alberta, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario and Saskatchewan) and in Yukon Territory. Provincial home builders' associations, except in Manitoba and Yukon Territory, also participated. There were three types of cooperation during the period:
  - Representatives from most provinces and Yukon Territory participated as members of regional R-2000 advisory committees;
  - In New Brunswick, Newfoundland and Labrador, Nova Scotia and Saskatchewan, the provincial governments and NRCan supported R-2000 through financial or in-kind contributions; and
  - In Manitoba and Yukon Territory, the provincial and territorial governments delivered R-2000 under a licensing agreement with NRCan.

EnerGuide for Houses

- Several provinces and Yukon Territory participated in the EnerGuide for Houses Advisory Committee.
- Yukon Housing Corporation and the Agence de l'efficacité énergétique du Québec are the delivery agents of EnerGuide for Houses in their jurisdictions, under licensing agreements with NRCan.

Federal Buildings Initiative (FBI)

- British Columbia and New Brunswick have replicated several elements of the FBI into programs aimed at improving the energy efficiency and environmental performance of their buildings.

Commercial Building Incentive Program (CBIP)

- Provinces and territories distributed information on CBIP. Provincial and territorial health and education departments were active participants in the program as eligible parties.

Canadian Industry Program for Energy Conservation (CIPEC)

- The excellence of the CIPEC concept and its ability to instigate positive change was affirmed when India chose the CIPEC model as the basis for the Indian Industrial Programme for Energy Conservation (IIPEC). Following CIPEC's lead, IIPEC is establishing a series of energy management sector task forces, including cement, pulp and paper and textiles. In April 2002, representatives of IIPEC toured Canadian facilities of CIPEC partners in Ontario and Quebec, joined a CIPEC Cement Task Force meeting and met with officials from the OEE and other federal departments, non-governmental organizations, academia and research labs. Two participants from the Indian delegation attended an OEE customized Dollars to $ense textile workshop.

Energy Innovators Initiative (EII)

- The EII relies on partners to promote energy efficiency and facilitate access to its members as well as to provide sectoral information. Partners include the Association of Canadian Community Colleges, the Canadian School Boards Association, the Canadian College of Health Service Executives, the Association des gestionnaires de parcs immobiliers institutionnels, the Hotels Association of Saskatchewan, the Alberta Hotel & Lodging Association, the Manitoba Hotel Association and the British Columbia & Yukon Hotels' Association. As well, a dynamic partnership has been established with BC Hydro to assist in identifying new retrofit projects with large energy users. Additionally, the EII works with the Agence de l'efficacité énergétique du Québec to facilitate program delivery to the province's institutional sector.

Equipment Energy Efficiency Regulations

- NRCan and five provinces (British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec) regulate the energy efficiency performance of prescribed equipment. They share information and consult through CSA International's Advisory Committee on Energy Efficiency.

Initiative to Purchase Electricity From Emerging Renewable Energy Sources

- The February 2000 federal budget announced that the Government of Canada would expand the pilot Green Power Initiative to procure $15 million of renewable energy over the next 10 years in Saskatchewan and Prince Edward Island. NRCan entered into discussions with SaskPower and Maritime Electric on the purchase of green power for federal facilities in the provinces they serve.

Residential Wood Combustion

- NRCan is a member of the Intergovernmental Working Group on Residential Wood Combustion, which is co-chaired by Environment Canada and the Newfoundland and Labrador Department of Environment. The Federal Smog Management Plan calls for four initial joint actions on residential wood combustion:
  - assess the effectiveness of pilot wood-stove change-out programs and consider options for a national program;
  - complete an update of CSA International standards on wood stoves, fireplace inserts and solid-fuel-burning central systems, and further the development of similar standards for fireplaces;
  - support public education on cleaner wood burning with advanced technologies and sustainable wood use; and
  - develop a federal regulation on residential wood combustion, focusing on cleaner-burning appliances.

- NRCan chairs the cross-jurisdictional steering committee that was responsible for the deployment of a Canada-wide education campaign on safe, clean and efficient residential wood heating. NRCan worked with health industry partners, the Canadian Lung Association, the Canadian Environmental Network and Fire Prevention Canada on the campaign, which ran from fall 2002 to March 2003.

Personal Vehicles

- NRCan completed anti-idling pilot projects with the cities of Mississauga and Sudbury, Ontario. The goal of the projects was to test the effectiveness of (a) municipal-based awareness campaigns promoting the benefits of not idling vehicles needlessly and (b) a Web-based tool kit of information to launch their own anti-idling campaigns. The results of the pilots provided a template for future campaign roll-outs in other Canadian cities.

Federal-Municipal Cooperation

- The town of Banff, Alberta, mandated the R-2000 Standard for new residential construction by the Banff Housing Corporation.
- A number of municipalities received financial incentive contributions in 2002–2003 under CBIP.
- A number of municipalities registered as Energy Innovators during the period, and some received financial assistance under the EII.

Green Municipal Funds

- The Green Municipal Funds were created in Budget 2000 by an endowment of $125 million to the Federation of Canadian Municipalities (FCM). The funds were doubled in Budget 2001 to the current total of $250 million – $50 million for the Green Municipal Enabling Fund (GMEF) and $200 million for the Green Municipal Investment Fund (GMIF).
- Cooperation takes place on several levels in the delivery of the Green Municipal Funds:
  - The Government of Canada signed an Agreement with the FCM, a non-profit organization, to deliver the Green Municipal Funds.
  - Moneys for the Green Municipal Funds endowment were provided equally by NRCan and Environment Canada who signed a Memorandum of Understanding.
  - Provincial, territorial and municipal officials cooperate to promote projects with innovative environmental solutions within municipalities across Canada because each municipal application must be accompanied by a provincial or territorial letter of support.

- The Government of Canada shares in the governance of the Green Municipal Funds, along with representatives from the public and private sectors, including municipal officials and technical experts, through participation on a Peer Review Committee and a governing Council. The FCM Board of Directors, with delegated GMF decision-making authority, reviews council recommendations and decisions.

International Cooperation

NRCan also cooperates with several international organizations and foreign governments. Canada benefits from this cooperation in two ways:

- Canada learns about improved ways of designing and delivering EAE programs; and
- This cooperation helps reduce trade barriers to energy-using products through the harmonization of energy efficiency tests and performance standards.

International Energy Agency (IEA)

The IEA, based in Paris, France, is an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD). The IEA is the key energy forum for its 26 member countries, which include Canada. IEA member governments have committed to sharing energy information, coordinating energy policies and cooperating in the development of rational energy programs. The IEA and its Governing Board are assisted in their work by several standing groups and special committees, which bring together energy specialists from member countries.

The Standing Group on Long-Term Cooperation (SLT) is the key committee on the policy side. The SLT develops policy analyses to promote conservation and the efficient use of energy, the increased use of alternatives to oil and other measures to increase long-term energy security while protecting the environment. The SLT also monitors energy developments in member countries and makes recommendations on energy policy through a regular series of individual country reviews. The Energy Efficiency Working Party (EEWP) of the SLT undertakes IEA work on specific issues related to energy efficiency. Canada is represented at the EEWP by NRCan's OEE.

Canada is an active member of the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET). CADDET is an international information network to help managers, engineers, architects and researchers find out about energy-using technologies that have worked in other countries. CADDET is part of an IEA Agreement known as the Energy and Environmental Technologies Information Centres (EETIC). Within the CADDET organization, Canada cooperated with some 10 OECD countries and the European Union during the reporting period.

Canada also collaborates with research centres in member countries on several agreements and programs oriented toward research and development (R&D) and technology.

Organisation for Economic Co-operation and Development

As a member of the OECD, Canada participates in the organization's analytical work to support member countries' national climate change policy development. As well, Canada cooperates with the OECD to conduct peer reviews of environmental conditions and the progress of each member country and to scrutinize efforts to meet domestic objectives and international commitments.

Research and Development

NRCan facilitates R&D and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities, including participating in various IEA tasks and supporting technical and trade-oriented workshops and conferences.

Mexico

NRCan signed a Memorandum of Understanding (MOU) on EAE cooperation with the Mexican Energy Secretariat in June 1996. The objective of the MOU is to contribute to the EAE objectives of Canada and Mexico by

- improving the design and delivery of EAE programs implemented or sponsored by NRCan and Mexico's National Commission for Energy Savings (Comisión Nacional para el Ahorro de Energía [CONAE]); and
- enhancing trade, investment and exchanges (technical and other) related to energy-efficient products, energy management services and alternative energy goods and services.

In November 2002, the OEE sponsored two Dollars to $ense workshops in Mexico City; one for industry and the other for the Ministry of Health. Mexican government officials and private sector participants were pleased with both workshops. The workshops aimed to enable participants to

- identify and capitalize on immediate savings opportunities;
- develop new, cost-saving energy management solutions;
- be more competitive while enhancing their corporate image;
- assemble a money-saving energy management team; and
- promote a more comfortable, more productive workplace.

NRCan also presented information on vehicle fuel efficiency at a November 2002 workshop organized by CONAE and Pemex in Mexico City.

Tunisia

For the reporting period, NRCan provided training to the Agence Nationale des Énergies Renouvelables (ANER) de Tunisie on the factorization method that NRCan uses in its Canadian analysis. This activity helped inform key decision-makers in Tunisia about Canada's energy efficiency efforts. The activity also supports bilateral relations with the Government of Tunisia.

United States

Motor Vehicle Fuel Efficiency and Fuels – NRCan and the U.S. Department of Energy (DOE) signed an MOU about road transportation, energy efficiency and alternative fuels. The MOU provides a formal mechanism for negotiating and harmonizing North American policy on fuel efficiency, fuel quality and alternative transportation fuels. The MOU provides a framework for sharing information and combining efforts on joint studies. In 2002–2003, completed studies included one on the potential for voluntary fuel economy standards in the United States and Canada, and another on vehicle and fuel transitions over the next 50 years.

A joint study sponsored by the DOE's Office of Policy and NRCan's OEE was published in February 2003 entitled *Examining the Potential for Voluntary Fuel Economy Standards in the United States and Canada*. This study reviewed the voluntary agreements in place in Europe and Japan, updated previous analysis of available fuel economy technologies and costs, and modelled the impact of different structures of voluntary agreement on individual manufacturers.

Under the MOU, a joint project was carried out to assess possible transitions in vehicle technologies and fuels through 2050. The project involved NRCan and DOE staff and several experts drawn from the Argonne National Laboratory, Oak Ridge National Laboratory and National Renewable Energy Laboratory. Several presentations have been given at conferences on the findings of this work.

United States and Mexico

NRCan continues to participate with the United States and Mexico in the North American Energy Working Group's Energy Efficiency Experts Group to promote the harmonization of energy efficiency test methods, mutual recognition of conformity assessment systems for energy efficiency standards and cooperation on trilateral energy efficiency labelling programs. During the review period, test standards for three products were assessed, and equivalent standards of performance were then instituted in Mexico. Work has begun to determine the prospects for Mexico's participation in the ENERGY STAR® high-efficiency program currently promoted in Canada and the United States. Other opportunities for harmonizing these types of programs are being explored.

Appendix 1:
NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 2002–2003

	(millions of dollars)
General Programs	**$10.4**
Outreach	
National Energy Use Database	
Community Energy Systems Program	
Energy Efficiency – Equipment	**8.8**
Energy Efficiency Standards and Regulations	
Equipment Labelling and Promotion	
EnerGuide for Industry	
Mine Ventilation	
Energy Efficiency – Buildings	**38.2**
R-2000 Standard	
Super E™ Program	
EnerGuide for Houses	
Housing Energy Technology Program	
Commercial Building Incentive Program	
Industrial Building Incentive Program	
Green Buildings Program	
Federal Buildings Initiative	
Federal Industrial Boiler Program	
Energy Innovators Initiative	
Buildings Program	
Building Energy Simulation Program	
Energy Efficiency – Industry	**41.3**
Industrial Energy Efficiency (Canadian Industry Program for Energy Conservation; Industrial Energy Innovators)	
Advanced Combustion Technologies	
Processing and Environmental Catalysis Program	
Industrial Process Engineering Program	
Industrial Process Integration Program	
Industry Energy Research and Development Program	
Emerging Technologies Program	
Energy Technologies for High-Temperature Processes	
Minerals and Metals Program	
Energy Efficiency – Transportation	**13.2**
Vehicle Efficiency	
Personal Vehicles	
Fleet Vehicles	
Federal Vehicles Initiative	
Canadian Lightweight Materials Research Initiative	
Alternative Energy – Transportation	**3.9**
Fuel-Cell-Powered Mining Vehicles	
Vehicle Fuels	
Transportation Energy Technologies Program	
Alternative Energy – Renewable Energy Sources	**18.5**
ENergy from the FORest (ENFOR)	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources	
Photovoltaic and Hybrid Systems Program	
Renewable Energy Capacity-Building Program	
Renewable Energy Deployment Initiative	
Renewable Energy Technologies Program	
Wind Power Production Incentive	
Total[1]	**$134.2**

[1]Total does not add due to rounding.

Appendix 2:
Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for the purpose of energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix B of NRCan's *Energy Use Data Handbook, 1990 and 1995 to 2001*.

FIGURE 2-1: Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.00	1.02	1.05	1.10	1.13	1.15	1.18	1.17	1.22	1.27	1.25
Actual energy use	1.00	0.98	1.00	1.02	1.06	1.07	1.11	1.12	1.09	1.13	1.17	1.14

FIGURE 2-2: Electricity Production From Renewable Sources

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gigawatt hours	3649	4134	4477	5362	5422	5855	6419	6599	7372	7418

FIGURE 4-1: Canadian Households by Type of Dwelling, 2001

	Number of households	Percent
Single detached	6 754 000	57
Apartments	3 631 000	31
Single attached	1 246 000	10
Mobile homes	266 000	2
Total	**11 897 000**	

FIGURE 4-2: Residential Energy Use by Purpose, 2001

	Energy Use (petajoules)	Percent
Space heating	775.9	58
Water heating	296.0	22
Appliances	185.9	14
Lighting	62.4	5
Space cooling	16.5	1
Total	**1336.7**	

Figure 4-3: Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.21	1.13	1.18	1.25	1.22
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.05	1.12	1.08	0.99	1.03	1.08	1.04

FIGURE 4-4: Annual Heating Consumption for Houses Constructed to Different Standards (From EnerGuide for Houses)

	Megajoules per year
R-2000 house	78 747
Model National Energy Code house (2002)	112 101
Typical new house (2002)	146 274
Typical existing house (1970)	216 812

FIGURE 4-5: Average Energy Consumption per Household (From R-2000 and EnerGuide For Houses)

Year built	Average energy consumption (gigajoules)
Pre-1946	277
1946–1960	207
1961–1970	200
1971–1980	192
1981–1990	181
1991–2000	160
2001–2003	148
All EGH in Canada	203
R-2000	103

FIGURE 4-6: Number of Eligible R-2000 Housing Starts, 1990 to 2002

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Number of R-2000 housing starts	504	519	1074	152	726	623	470	488	282	250	280	268	374

FIGURE 4-7: National Trends in Air Leakage in Houses (R-2000 and EnerGuide for Houses), 1985 to 2002

Year built	Average air changes per hour at 50 pascals
1985–1987	5.3
1988–1990	5.1
1991–1993	4.5
1994–1996	4.4
1997–1999	3.6
2000–2002	3.5
R-2000	1.1

FIGURE 4-8: Evaluations Under EnerGuide for Houses (number of houses)

Year of EGH evaluation	2002–2003	2001–2002	2000–2001	1999–2000	1998–1999
Houses retrofitted (B evaluation)	1153	709	607	225	832
Houses evaluated but not re-evaluated (A evaluation)	16 564	11 087	11 509	9106	3672

Note: Under EnerGuide for Houses, homes are evaluated to determine the potential for energy savings (an A evaluation). After renovations implementing program recommendations have taken place, some homes are revisited to determine the actual energy savings (a B evaluation).

FIGURE 4-9: Residential Energy Use and Energy Savings per Household (gigajoules per year per house)

Period of construction	Pre–1945	1945–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2002	**Average**
Energy use pre-evaluation	286	216	205	203	201	181	168	**215**
Evaluation-identified energy savings	111	74	65	66	53	39	40	**70**
Actual energy savings after renovations	64	41	40	37	32	28	29	**41**

FIGURE 4-10: Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 2001 (petajoules)

	Regulated	Unregulated
Space conditioning	555.19	237.23
Water heating	293.25	2.76
Appliances and lighting	120.268	127.928
Total	**968.708**	**367.918**

FIGURE 4-12: Average Energy Consumption of New Appliances, 1990 and 2001 Models (kilowatt hours per year)

Appliance type	1990	2001
Freezers	714	384
Ranges	772	763
Dishwashers	1026	634
Refrigerators	956	559
Clothes dryers	1103	916
Clothes washers	1218	810

FIGURE 4-14: Impact of EnerGuide Labelling: Total Energy Savings and GHG Emissions Reductions Attributable to EnerGuide for Equipment, 1990 to 2000

Year	Total energy savings (GWh)	GHG reductions (kt CO_2e)
2000	91.1	49.3
1999	83.8	45.4
1998	62.4	33.8
1997	46.7	25.3
1996	43.7	23.7
1995	40.3	21.8
1994	43.2	23.4
1993	41.9	22.6
1992	40.1	21.7
1991	21.7	11.8
1990	16.4	8.9
Cumulative Annual	**531.3**	**287.7**

FIGURE 5-1: Commercial and Institutional Energy Use by Building Type, 2001

Building type	Energy use (petajoules)	Percent
School	89.24	8.53
Health care institution	102.70	9.82
Religious institution	15.36	1.47
Other institution	51.29	4.90
Office	340.53	32.56
Retail organization	222.76	21.30
Hotel and restaurant	84.03	8.03
Recreational facility	64.54	6.17
Warehouse	75.53	7.22
Total	**1045.98**	

FIGURE 5-2: Commercial and Institutional Energy Use by Purpose, 2001

Purpose	Energy use (petajoules)	Percent
Space heating	565.84	53
Water heating	70.37	7
Auxiliary equipment	79.20	8
Auxiliary motor	121.16	12
Lighting	154.02	15
Space cooling	55.41	5
Total	**1046.00**	

FIGURE 5-3: Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.05	1.06	1.11	1.11	1.13	1.15	1.14	1.11	1.15	1.26	1.25
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.13	1.15	1.09	1.13	1.24	1.22

FIGURE 5-4: Energy Use in Commercial Buildings, 1999

	Megajoules per m^2 per year
C-2000 projects	553
CBIP target	829
Model National Energy Code	1105
New buildings*,**	1328
All buildings**	1585

*1990–1999

**Source: Commercial and Institutional Building Energy Use Survey, 2000. Estimates relate only to the surveyed area of populations over 175 000 and in Atlantic Canada populations over 50 000.

FIGURE 5-5: Estimated Average GHG Reductions by Institution Under CBIP, 2002 to 2003

Building type	Average GHG savings (tonnes per year)
Other	121.2
Multi-unit residential building	70.4
Retail	144.9
Office	119.7
Health	221.0
Education	300.3

FIGURE 6-1: Industrial Energy Use by Subsector, 2001

	Energy use (petajoules)	Percent
Pulp and paper	880.1	28.7
Other manufacturing	549.1	17.9
Mining	521.6	17.0
Petroleum refining	311.3	10.2
Smelting and refining	246.1	8.0
Iron and steel	224.5	7.3
Chemicals	201.3	6.6
Cement	63.5	2.1
Construction	47.8	1.6
Forestry	18.3	0.6
Total	**3063.6**	

FIGURE 6-2: Cost of Energy to Industry as a Percentage of Total Production Cost, 2001

Industry subsector	Energy cost/ Total production cost (percent)
Cement	38.49
Chemicals	13.75
Pulp and paper	13.32
Aluminum	13.12
Iron and steel	12.48
Petroleum refining	2.18
Transportation equipment manufacturing	0.84

Note: These reflect as accurately as possible the current definitions in the QRESD.

FIGURE 6-3: Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1995 to 2001 (index: 1995 = 1.0)

	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.00	1.04	1.05	1.10	1.14	1.11
Actual energy use	1.00	1.03	1.03	1.01	1.04	1.07	1.03

FIGURE 6-4: Industrial Energy Innovators and Action Plans, 1999–2000 to 2002–2003

	1999–2000	2000–2001	2001–2002	2002–2003
Number of active Innovators	15	53	24	77
Number of Innovators with action plans	79	105	134	94

FIGURE 6-5: Mean Five-Year Increases in Energy Consumption, CIPEC Participants vs. Non-Participants

	Percent
Participants	2.2
Non-participants	5.2

FIGURE 6-6: Level of Participation in Elements of CIPEC

CIPEC element	Percent of CIPEC participants
Heads Up CIPEC newsletter	59
CIPEC Web site	45
Dollars to $ense workshops	42
Boiler and heater guide	25
Motor systems assesment	25
Sector energy efficiency guide	25
Employee awareness kit	23
Sector benchmarking studies	20
CIPEC Task Force meetings	18
Energy sector days	10

FIGURE 6-7: Estimated Reduction in CO_2 Emissions From Motor Regulations, 2000 to 2020

	2000	2005	2010	2020
Reduction in CO_2 emissions (Mt)	0.56	1.33	2.03	2.14

FIGURE 7-1: Transportation Energy Use by Mode, 2001

	Energy use (petajoules)	Percent
Passenger light vehicle	1030.6	45.25
Passenger bus	64.2	2.82
Passenger aviation	218.7	9.60
Passenger rail	3.0	0.13
Freight truck	675.9	29.68
Freight marine	123.2	5.41
Freight rail	78.7	3.46
Off-road	83.1	3.65
Total	**2277.4**	

FIGURE 7-2: Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	0.97	0.99	1.03	1.10	1.13	1.16	1.21	1.25	1.29	1.32	1.31
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22	1.21

FIGURE 7-3: Market Shares of New Passenger Car and Light Truck Sales, 1990 to 2001 (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Passenger car market share	75.8	76.3	75.3	72.8	70.4	68.4	65.8	62.8	62.7	63.5	64.4	65.1
Light truck market share	24.1	23.7	24.7	27.2	29.6	31.6	34.2	37.2	37.3	36.5	35.6	34.9

FIGURE 7-4: New-Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 2000 (index 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
L/100 km	1.00	1.00	1.01	1.00	1.00	0.99	0.97	0.98	0.96	0.99	0.97
L/100 km/kg	1.00	1.00	1.01	0.99	0.96	0.91	0.92	0.93	0.92	0.91	0.90
L/100 km/hp	1.00	0.98	0.95	0.93	0.91	0.85	0.82	0.82	0.79	0.79	0.76

FIGURE 7-5: Company Average Fuel Consumption (CAFC) vs. Canadian Voluntary Standards (litres/100 km)

Model year	Truck standard (11.4 L/100 km)	Trucks CAFC	Car standard (8.6 L/100 km)	Cars CAFC
1990	11.8	11.4	8.6	8.2
1991	11.6	11.1	8.6	8.0
1992	11.6	11.3	8.6	8.1
1993	11.5	11.1	8.6	8.1
1994	11.5	11.5	8.6	8.2
1995	11.4	11.5	8.6	7.9
1996	11.4	11.3	8.6	7.9
1997	11.4	11.3	8.6	8.0
1998	11.4	11.4	8.6	7.9
1999	11.4	11.3	8.6	7.9
2000	11.4	11.1	8.6	7.7
2001	11.4	11.1	8.6	7.9
2002	11.4	11.1	8.6	7.9

FIGURE 7-6: Vehicle Fuel Efficiency Awareness (percent)

Year	Awareness of program activities (general public)	Recollection of information on how to reduce vehicle fuel consumption (general public)	New vehicles in showroom with EnerGuide label	New vehicles on lot with EnerGuide label
1998	9	30	0	0
1999	0	0	47	64
2001	0	0	56	77
2002	16	36	0	0

FIGURE 7-7: Number of New Drivers Educated Using the Auto$mart Student Driving Kit

Year	Number of new drivers educated
1997–1998	92 700
1998–1999	105 975
1999–2000	120 600
2000–2001	147 150
2001–2002	171 225
2002–2003	204 975

FIGURE 7-9: Drivers Trained and Participation in the Fleet Vehicles Initiative

Year	Drivers trained	FV members
1997–1999	51 000	946
1999–2000	53 000	1068
2000–2001	112 846	1643
2001–2002	125 000	2707
2002–2003	149 000	2805

FIGURE 8-1: Canadian Wind Power Capacity, 1990 to 2002 (MW)

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	0	0	19	19	20	20	21	24	124	137	214	230

FIGURE 9-1: GHG Emissions Reductions From Federal Operations*

	1990	1998	2000	2001	2002	2010 Target
GHG emissions (kt CO_2e)	3950	3184	3064	2987	n/a**	2742

* All values have changed as a result of a change to the 1998 baseline.

** Data are not yet available for 2002/2003 fiscal year.

FIGURE 9-2: Annual Energy Savings From the FIBP, 1991–1992 to 2002–2003

	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003
Terajoules per year	20	50	40	70	90	80	77	77	93	103	112	117

FIGURE 9-3: Federal Fleet Size and Fuel Consumption, 1995–1996 to 2001–2002

	1995–1996	1997–1998	1999–2000	2001–2002
Number of vehicles	24 854	22 796	22 462	23 313
Litres of gasoline equivalent (thousands)*	88 725	75 684	78 281	63 300

*Gasoline equivalent is computed by dividing the lower heating value of the alternative fuel by the lower heating value of gasoline and multiplying this result by the alternative fuel consumption value.

FIGURE 9-4: Purchases of ATF Vehicles for the Federal Fleet, 1997–1998 to 2001–2002

	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002
Number of vehicles	131	161	181	180	126

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